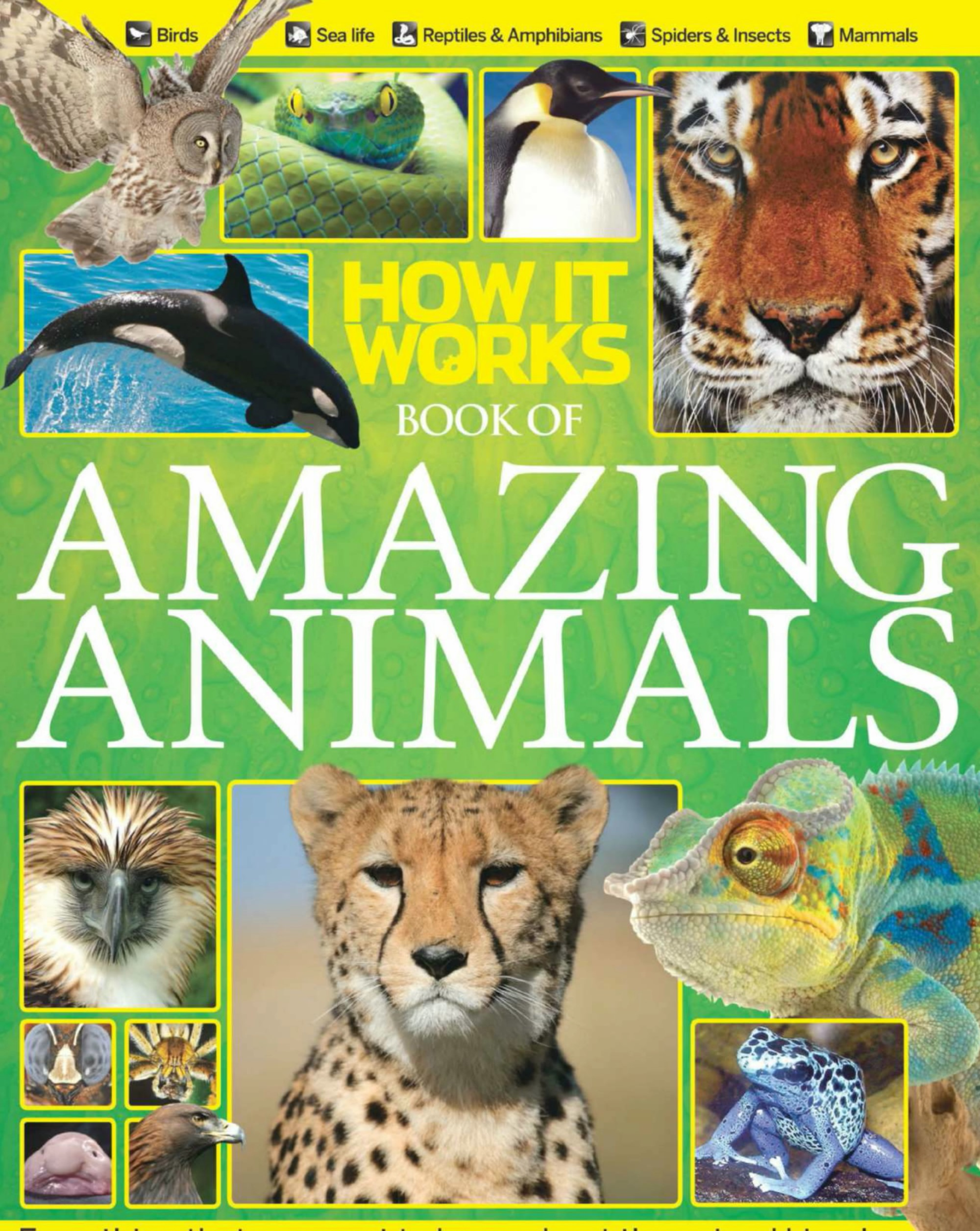
Birds Sea life Reptiles & Amphibians Spiders & Insects Mammals



HOW IT WORKS
BOOK OF
AMAZING ANIMALS

Everything that you want to know about the animal kingdom

Welcome to

HOW IT WORKS

BOOK OF

AMAZING ANIMALS

From their single-celled origins, through the Cambrian explosion and right up to the emergence of recognisable fauna and flora, the organisms that populate our world have continually pushed their limits – adapting and developing organs, limbs and behaviours in response to environmental and social pressures – and demonstrate a tenacity for life that really is sublime. In celebration of the sheer diversity of animals on Earth today, we've gathered together some of the most amazing creatures and gotten right under their skins (or exoskeletons!) – so we can show you exactly how they work. Creatures of the deep, the land, the air – all are explored and their natural talents explained. Beautifully illustrated diagrams detail everything from the tactics of a lion attack to the anatomy of a crocodile, while high impact photography puts you face to face with living wonders. Packed full of facts and tackling some of the greatest animal mysteries, this bookazine will show you just how amazing our cousins in the animal kingdom are.

HOW IT WORKS
BOOK OF
AMAZING ANIMALS

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IMAGINEER OF THE YEAR
DANIELLE DIXON

IMAGINE PUBLISHING

TEAM OF THE YEAR
BOOKAZINES

HOW IT WORKS BOOK OF AMAZING ANIMALS

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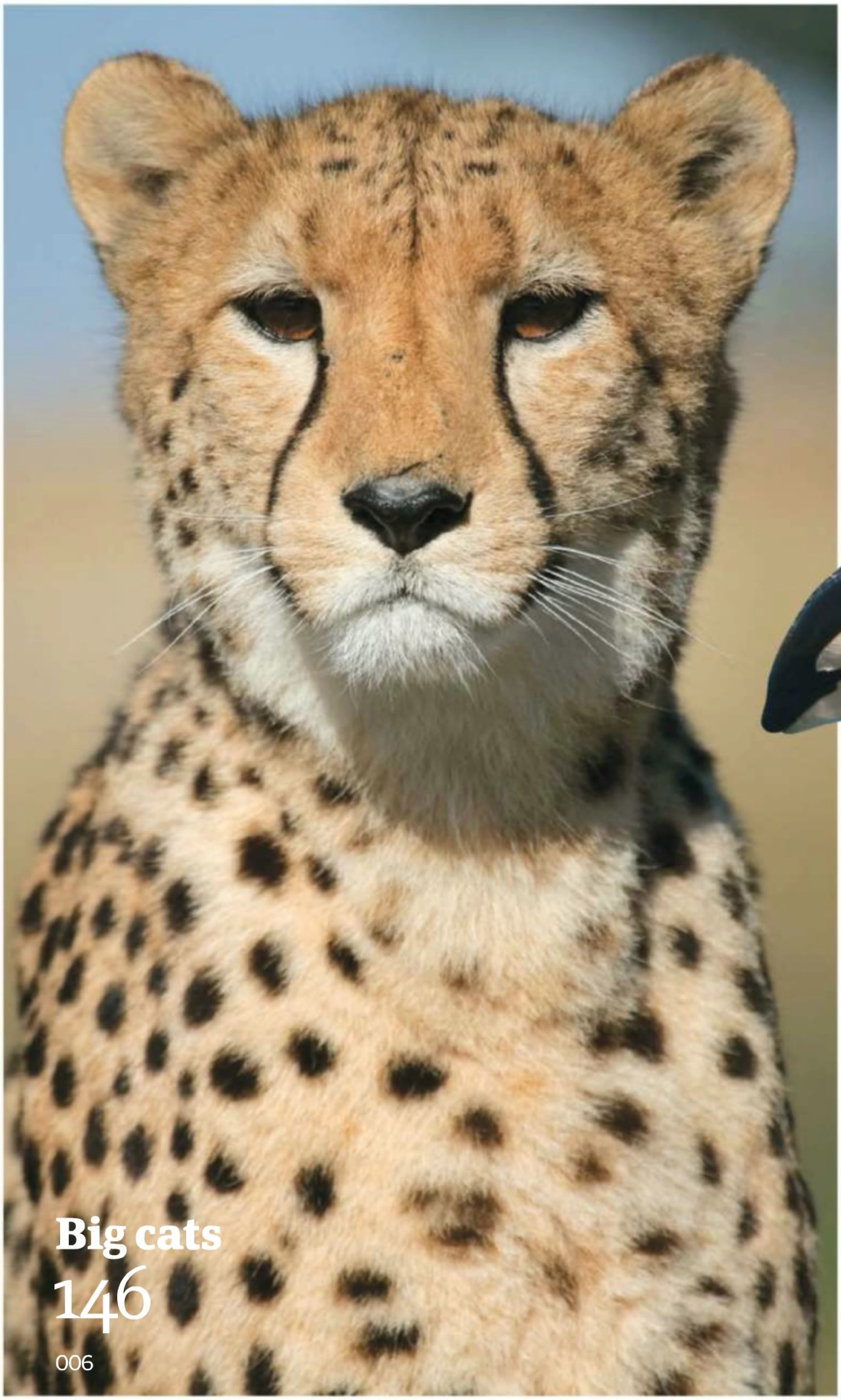

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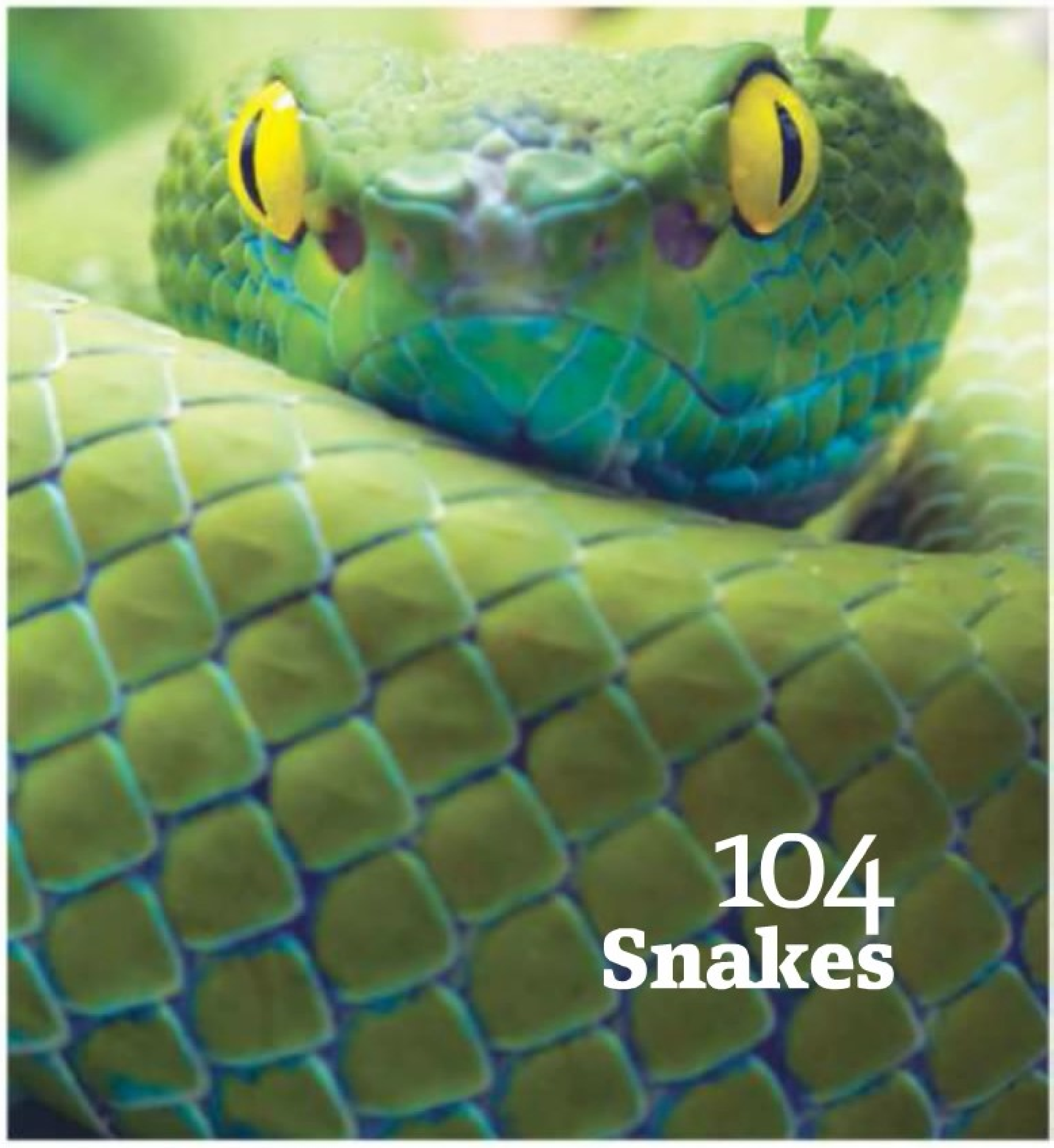

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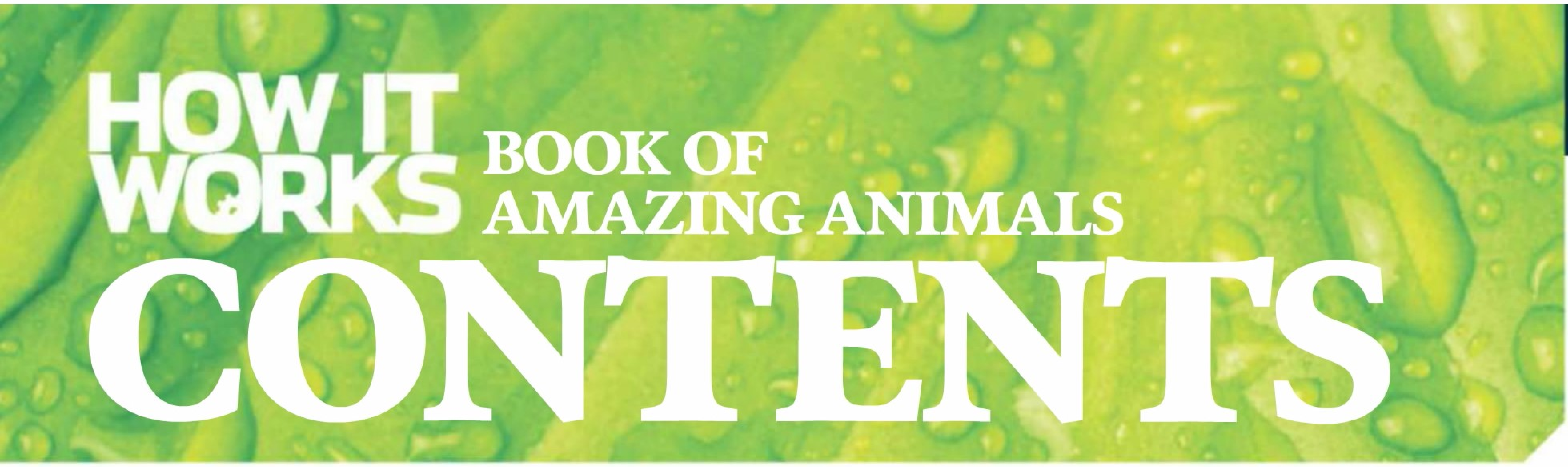

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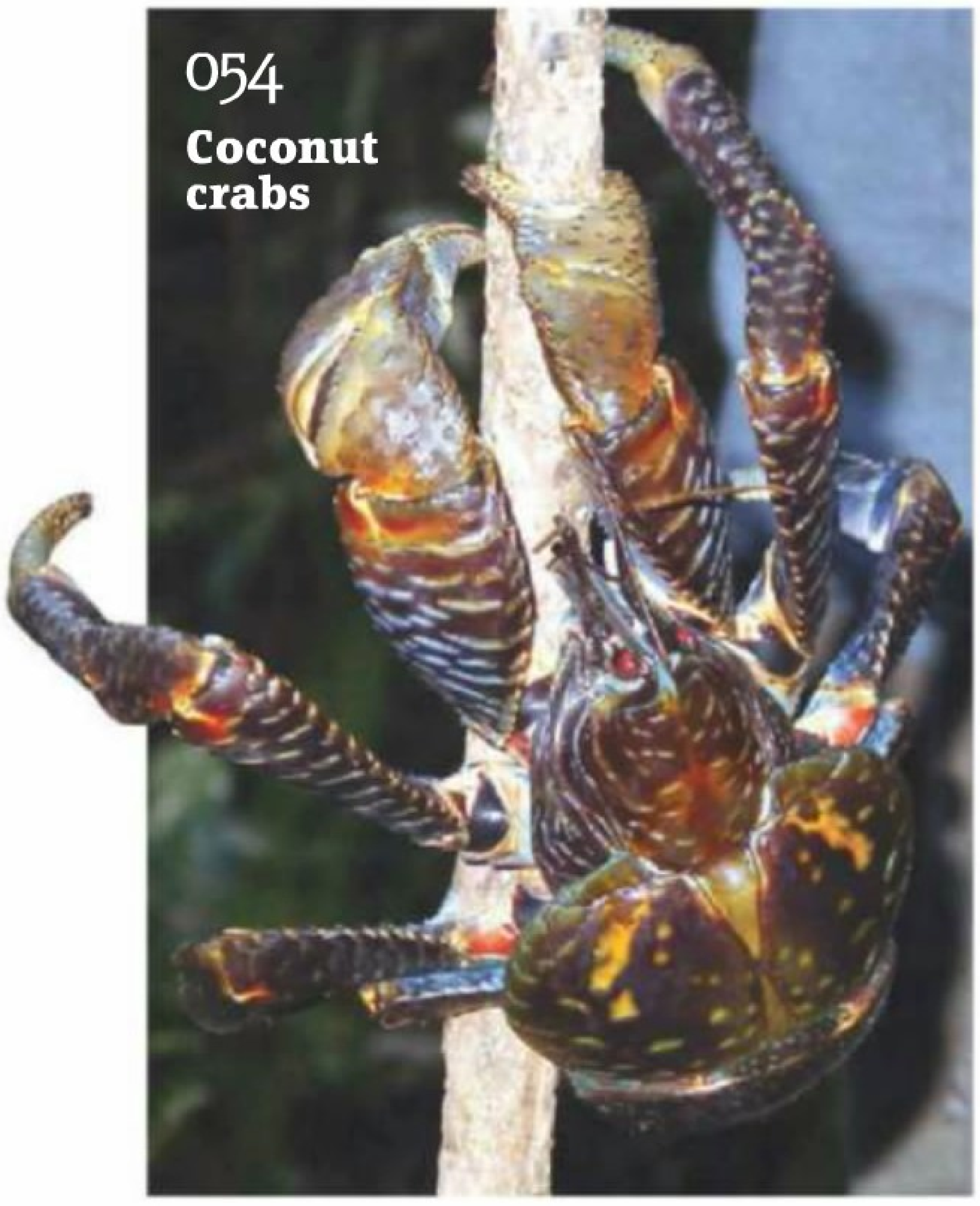

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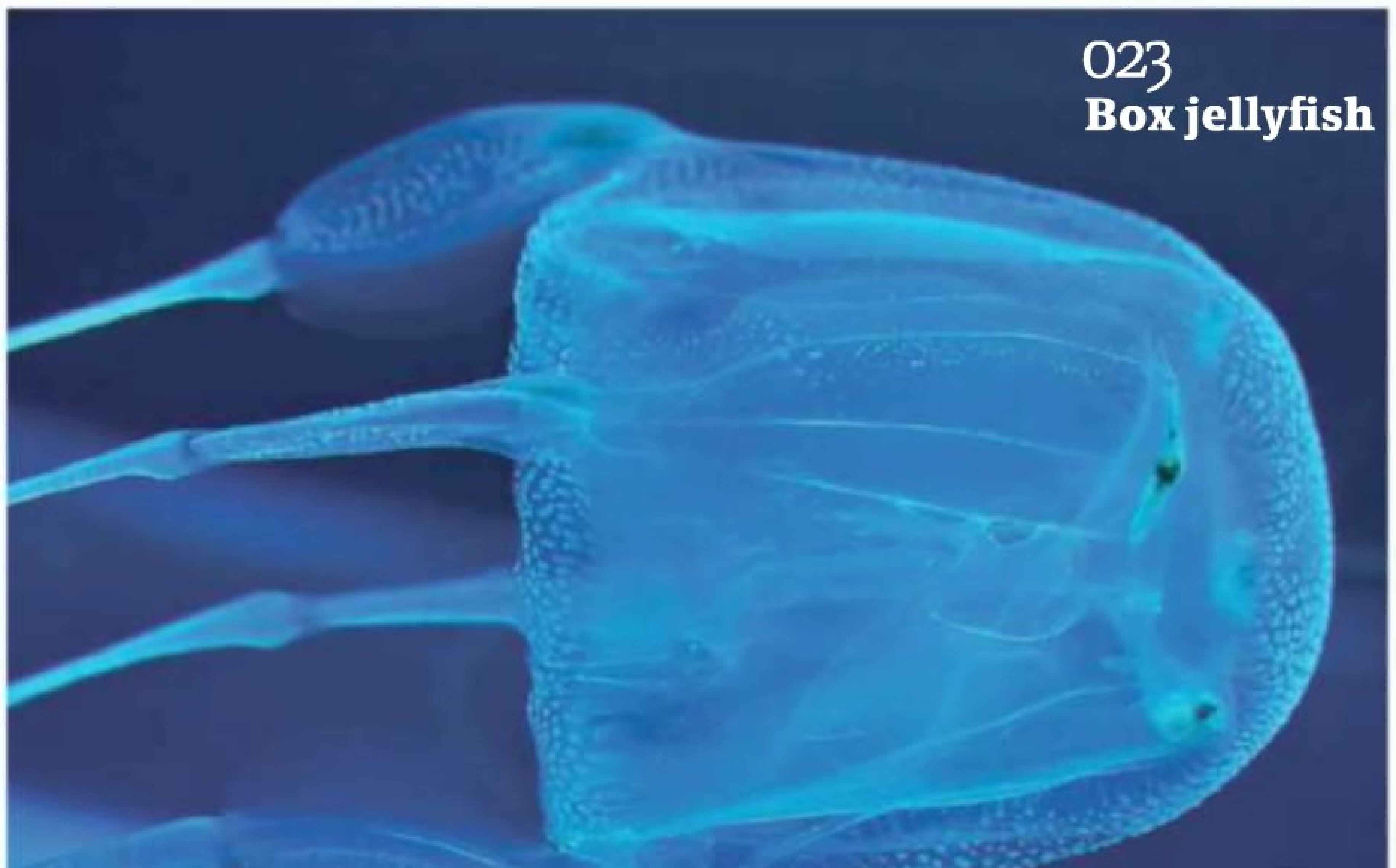

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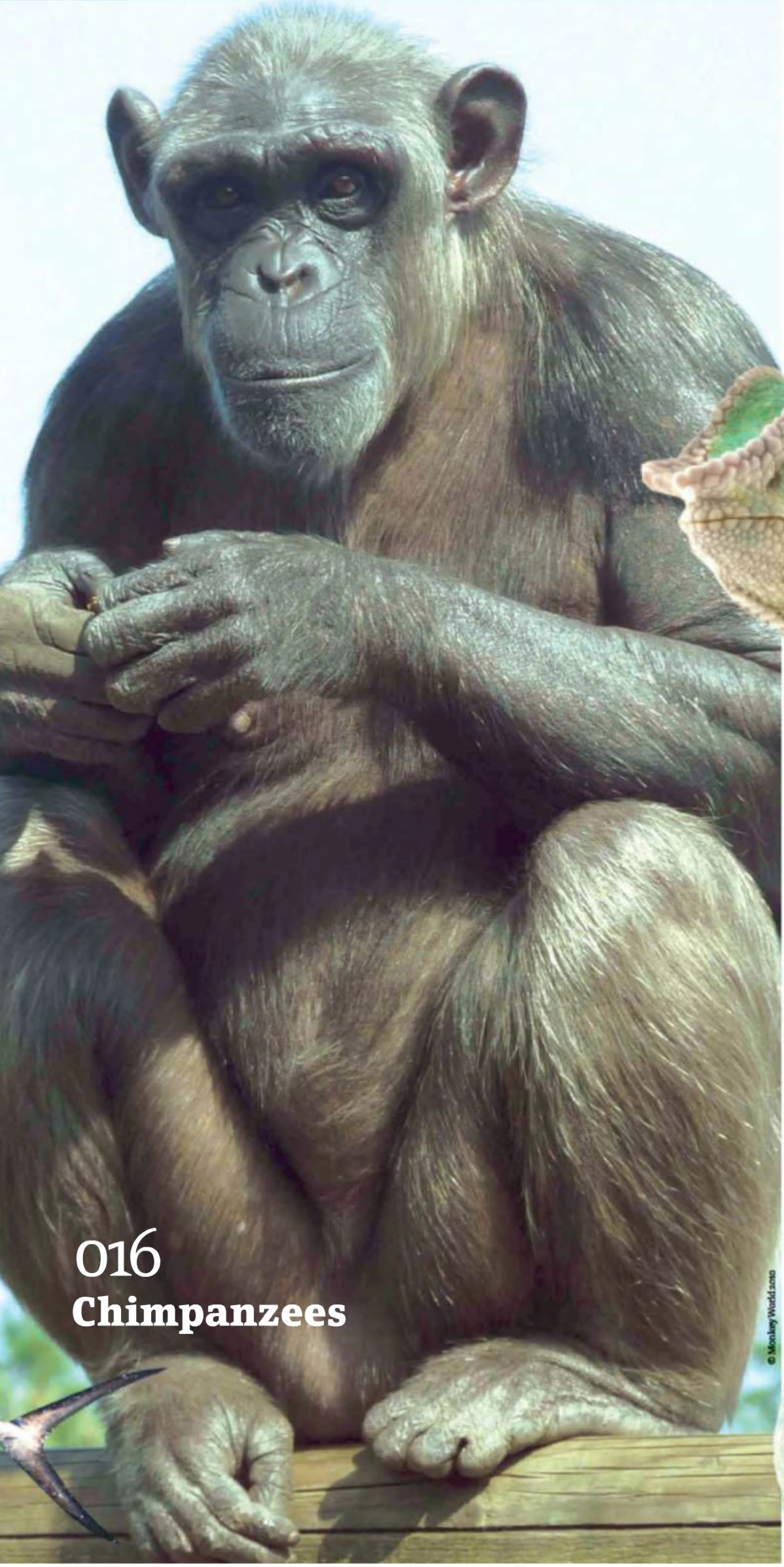

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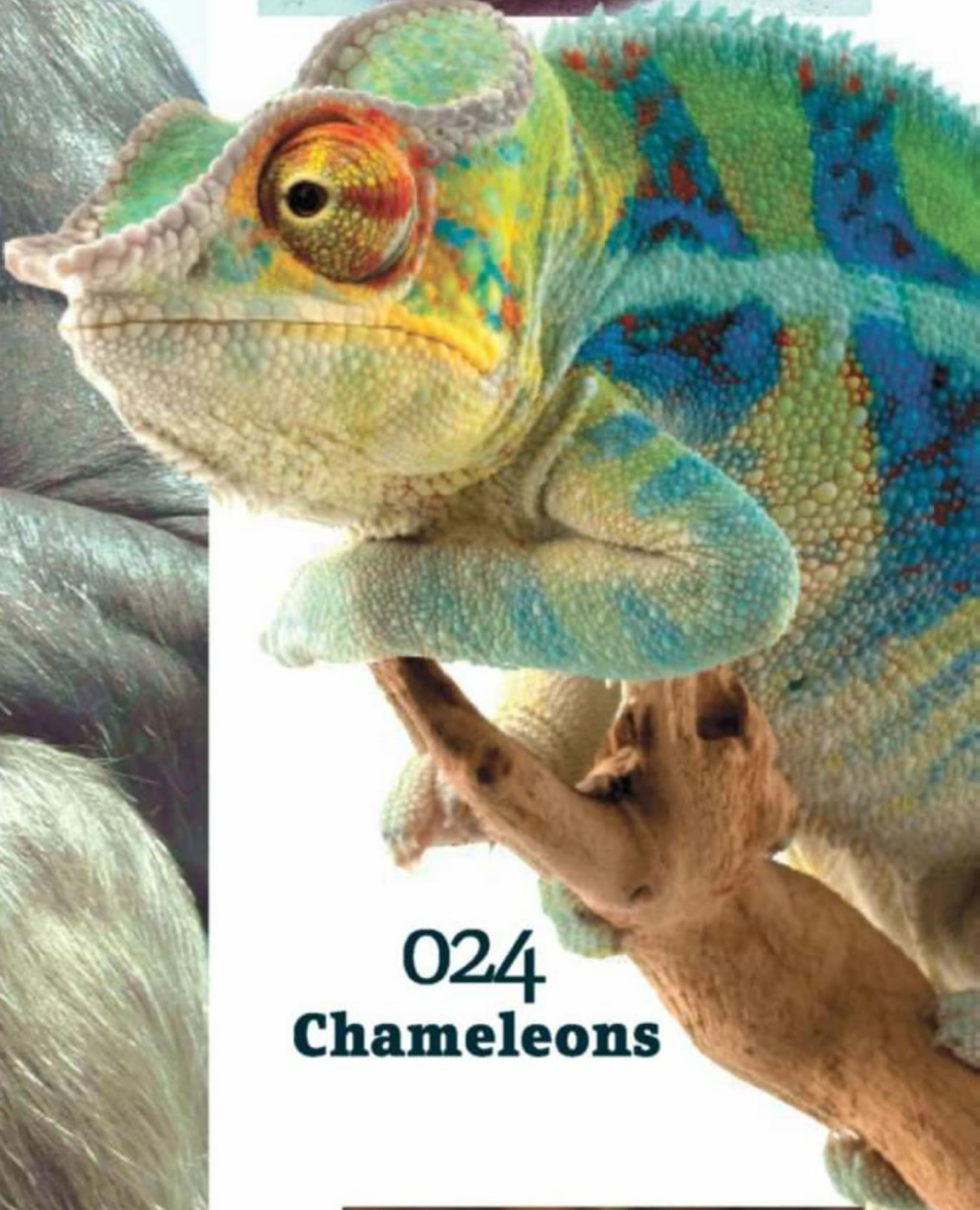

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Pronghorn antelope
57mph

World's fastest animals

The arms race of hunter and hunted is a ferocious battleground, with different species furiously evolving to remain, literally, one step ahead of the competition. We pit these speed demons against each other in the ultimate animal shootout

Cheetah

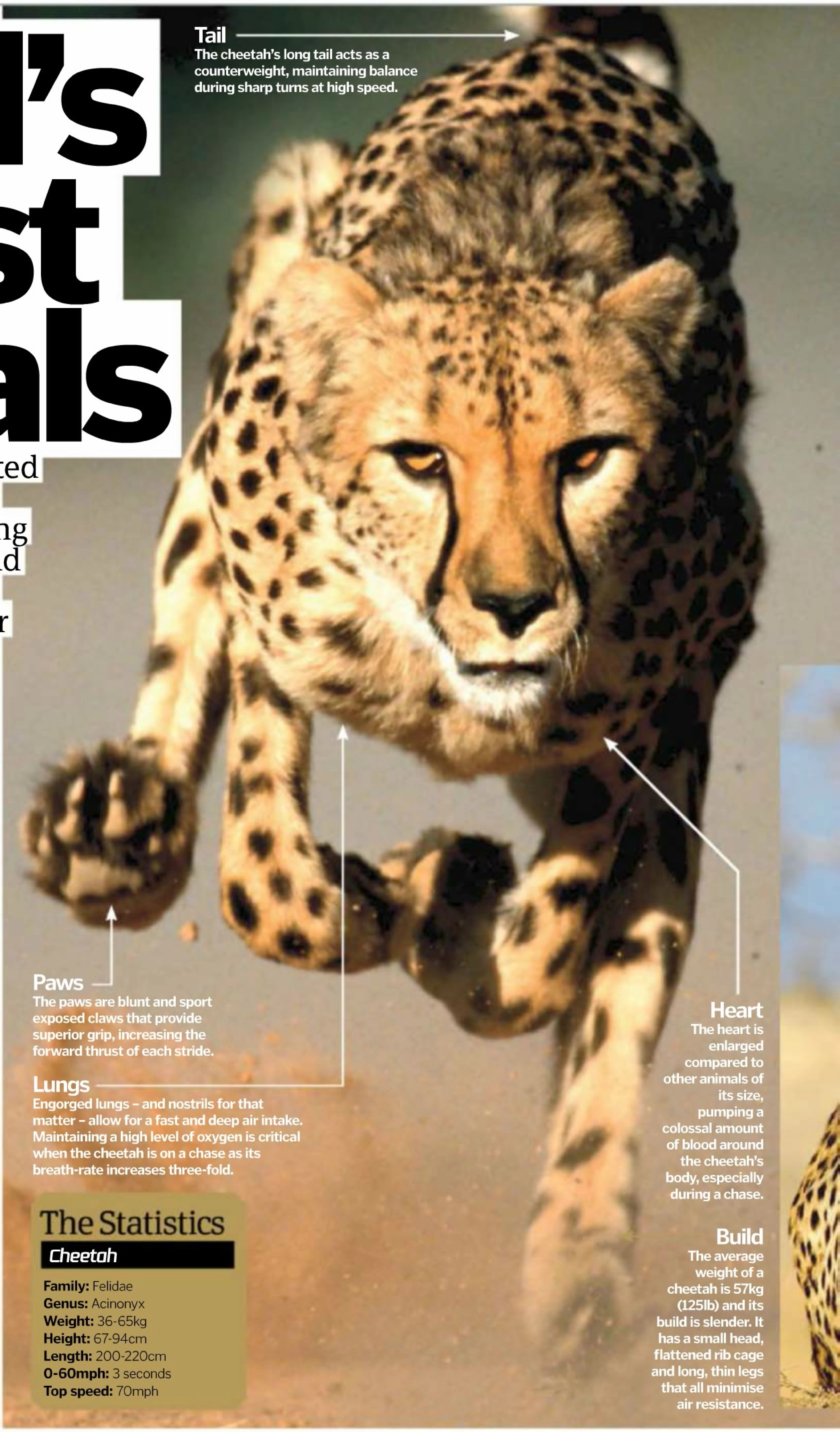
Accelerating to speeds of 70mph, the cheetah is the quickest on four legs!

Cheetahs are one of the fastest animals on Earth and have a terrifyingly quick 0-60 time of a mere three seconds. Cheetahs are unique in the fact that they have evolved to such a degree in order to maximise their speed, they regularly risk brain damage and starvation due to the great physical demands it places on their anatomy. The cheetah is fast – the fastest land animal on Earth – but that speed comes at a great price.

For example, lungs, nostrils and heart are all enlarged within the cheetah to ensure it can process enough oxygen and blood to maintain its explosive speed. However, it can only process this for short periods of time and at the close of a lengthy chase not only does it skirt dangerously close to oxygen deprivation but it must rest post-kill before it eats, leaving plenty of time for scavengers to surround it. In addition, while its muscle fibre is honed and holds superb elasticity, its physique is slender and lightweight, leaving it vulnerable to broken limbs and completely defenceless against a larger and heavier rival such as a lion or tiger.

Due to these facts – as well as through human-caused habitat loss and predation – cheetah numbers are dwindling and the species is currently endangered in many African countries.

Black mamba
12mph


Tail
The cheetah's long tail acts as a counterweight, maintaining balance during sharp turns at high speed.

Paws
The paws are blunt and sport exposed claws that provide superior grip, increasing the forward thrust of each stride.

Lungs
Engorged lungs – and nostrils for that matter – allow for a fast and deep air intake. Maintaining a high level of oxygen is critical when the cheetah is on a chase as its breath-rate increases three-fold.

Heart
The heart is enlarged compared to other animals of its size, pumping a colossal amount of blood around the cheetah's body, especially during a chase.

Build
The average weight of a cheetah is 57kg (125lb) and its build is slender. It has a small head, flattened rib cage and long, thin legs that all minimise air resistance.

The Statistics

Cheetah

Family: Felidae
Genus: Acinonyx
Weight: 36-65kg
Height: 67-94cm
Length: 200-220cm
0-60mph: 3 seconds
Top speed: 70mph

5 TOP FACTS
CHEETAHS

Lightweight
1 The average weight of a cheetah is 125 pounds. This is actually a fraction of the weight of other big cats, with an average lion weighing more than 400 pounds.

Threat
2 All over Africa, Asia and India cheetah populations are in sharp decline. In 1990 there were roughly 100,000 individuals worldwide, now there are roughly 10,000.

Sexist
3 Baby cheetahs are brought up solely by the female parent, who raises them in isolation from any male. It takes roughly 18 months for a cheetah cub to reach maturity.

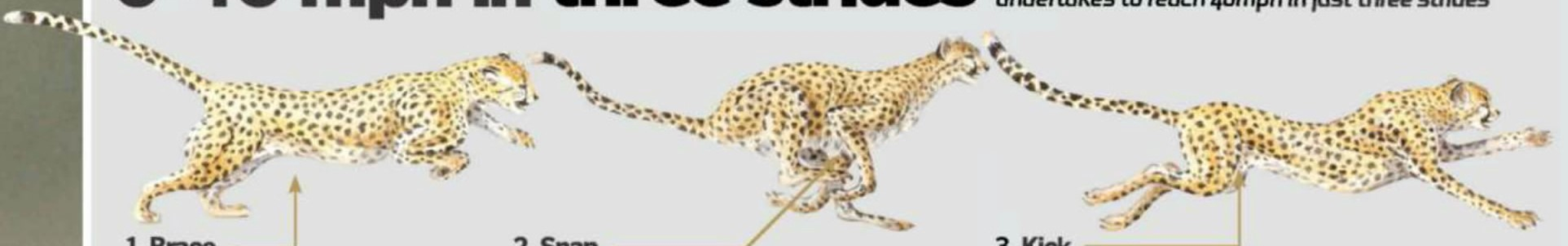
Hakuna matata
4 Cheetah's have a broad diet, ranging from antelope to springhare and game birds. However, one of their most common food supplies is the slow and fat warthog.

Habitat
5 Cheetahs tend to favour vast expanses of land where prey is abundant and easy to spot. However, cheetahs can be found in a variety of habitats including grasslands.

DID YOU KNOW? *Marine biologists postulate that the sailfish's large dorsal fin is used for cooling purposes as well as stability*

0-40 mph in three strides

Check out the three stages a cheetah undertakes to reach 40mph in just three strides



1. Brace
The cheetah employs its hard, ridged footpads and blunt, non-retractable claws to maximise traction with the ground. Its spine curves, coil-like, and its head drops a fraction.

2. Snap
The spine uncoils and snaps straight, driving the hind legs into the earth and pushing the cheetah forward. The honed, slender muscles expand in conjunction, adding greater elasticity and drive to the forward thrust.

3. Kick
The combined spine and leg muscles give the cheetah an incredibly broad swing range and propel it 7.6 metres (25 feet) through the air in a colossal bound. At the culmination of the bound one foot is replanted onto the earth and the process is repeated. The cheetah completes three strides a second.

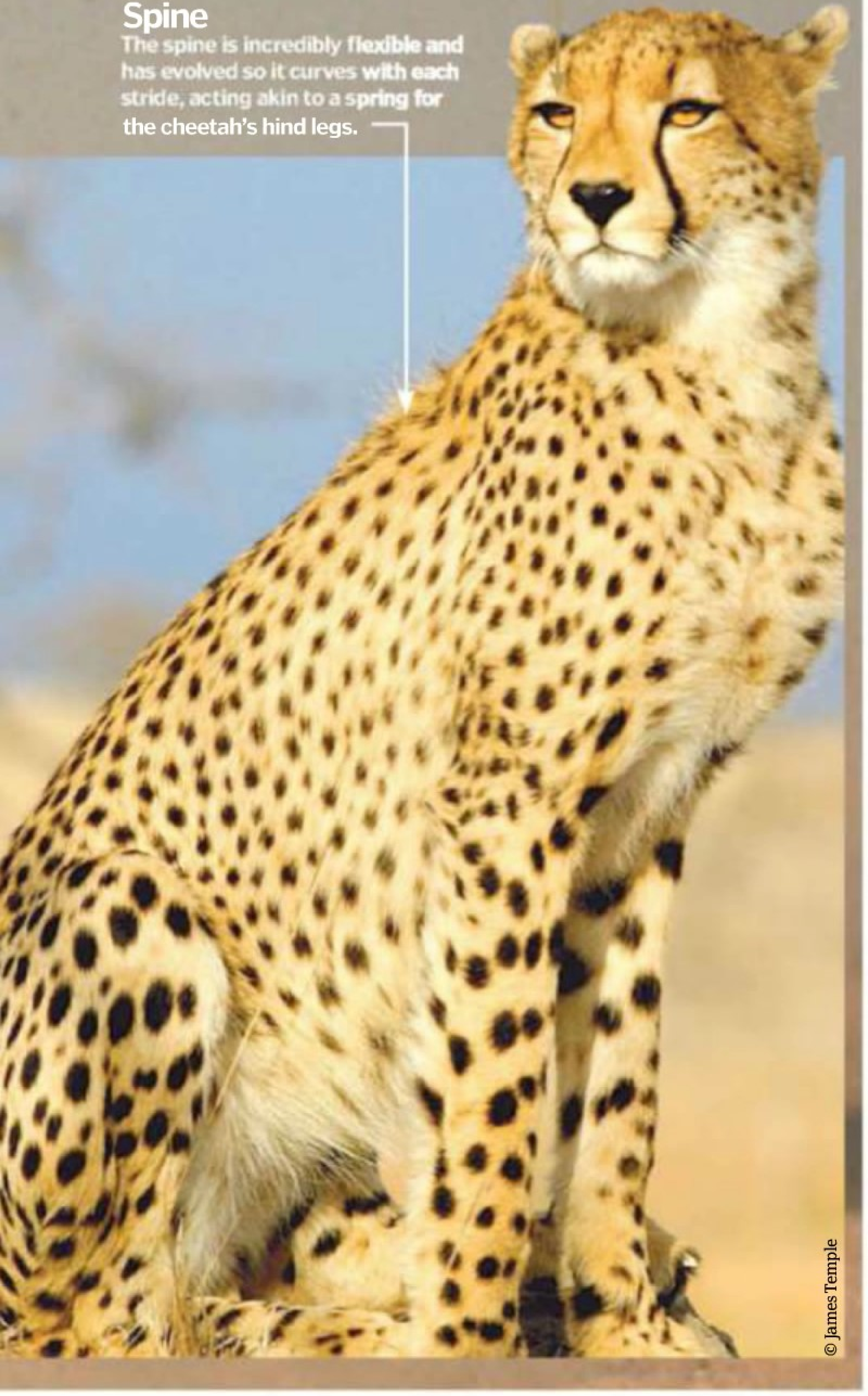
© DK Images

Cheetah anatomy

Just what makes it the fastest thing on four legs?

Eyes
The cheetah's eyes are long to provide a wide-angle view of its surroundings. This provides them with excellent vision when stalking and chasing prey in the native habitat of open plains.

Spine
The spine is incredibly flexible and has evolved so it curves with each stride, acting akin to a spring for the cheetah's hind legs.



© James Temple

The sailfish can rapidly turn its body light blue with stripes when excited, confusing its prey and making capture easier

Long nose
The sailfish's elongated bill is similar to a swordfish's and marlin's, placing it in the category of billfish.

Sailfish

Capable of swimming for long periods of time at over 40mph, and with a recorded top speed of over 70mph, the sailfish is the ocean's fastest animal

With a top speed on par with that of a cheetah, the sailfish is lightning fast and one of the most difficult-to-catch fish in the world. With its stiffened, tapered body and scissor-shaped caudal fin, the sailfish is built for speed – a speed that comes courtesy of a rapid and ferocious flicking of its tail. Indeed, during a chase to consume fish, crustaceans or cephalopods, the sailfish will flick its tail back and forth hundreds of times, utilising the powerful muscles which run down its compressed body.

As with the peregrine falcon, the sailfish's speed is also aided by its ability to retract parts of its body, in this instance its various fins (notably the large dorsal fin that adds over a foot onto its overall height). This feature helps it reduce the effects of drag and minimise resistance to its movements.

Its spine is also very flexible and, as with the cheetah, allows it to generate increased thrust through the rapid curves it bends its torso into while swimming.

The Statistics

Sailfish

Family: Istiophoridae
Genus: Istiophorus
Weight: 90kg
Height: 70cm
Length: 1.2-1.5m
0-60mph: Not recorded
Top speed: 70mph

Streamlined
Sailfish have incredibly sleek and streamlined bodies.

© anon09

The fastest animals on Earth are…

Here's a the list of the most super-fast critters on the planet

FASTEST FISH	
Sailfish	68mph (110kph)
Marlin	50mph (80kph)
Wahoo	48mph (78kph)
Tunny	46mph (74kph)
Bluefish tuna	44mph (70kph)

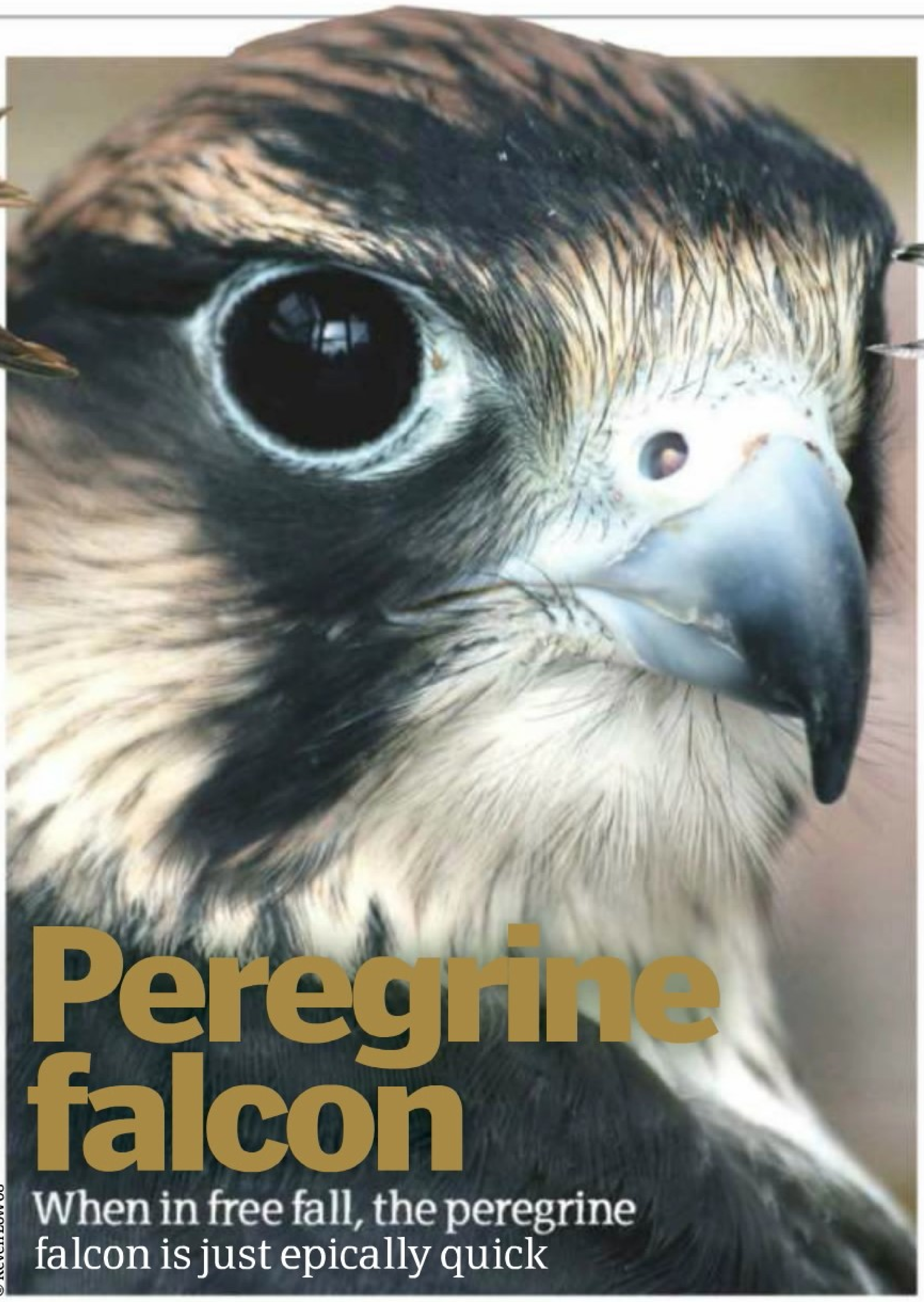
FASTEST LAND INSECTS	
Tiger beetle	5.6mph (8.4kph)
Cockroach	3.4mph (5.4kph)

FASTEST BIRDS	
Peregrine falcon	200mph (322kph)
Spine-tailed swift	106mph (171kph)
Frigatebird	95mph (153kph)
Spur-winged goose	88mph (142kph)
Red-breasted merganser	80mph (129kph)

FASTEST MAMMALS	
Cheetah	71mph (114kph)
Pronghorn antelope	57mph (95kph)
Springbok	50mph (80kph)
Blue wildebeest	50mph (80kph)
Lion	45mph (72kph)

FASTEST REPTILES	
Spiny-tailed iguana	21mph (34kph)
Black mamba	12mph (20kph)

Sources: American Journal of Zoology, University of Michigan, Seattle Zoo, American Journal of Physiology, National Geographic, US Fish and Wildlife Service, Forest Preserve of Illinois



© Keven Low 08

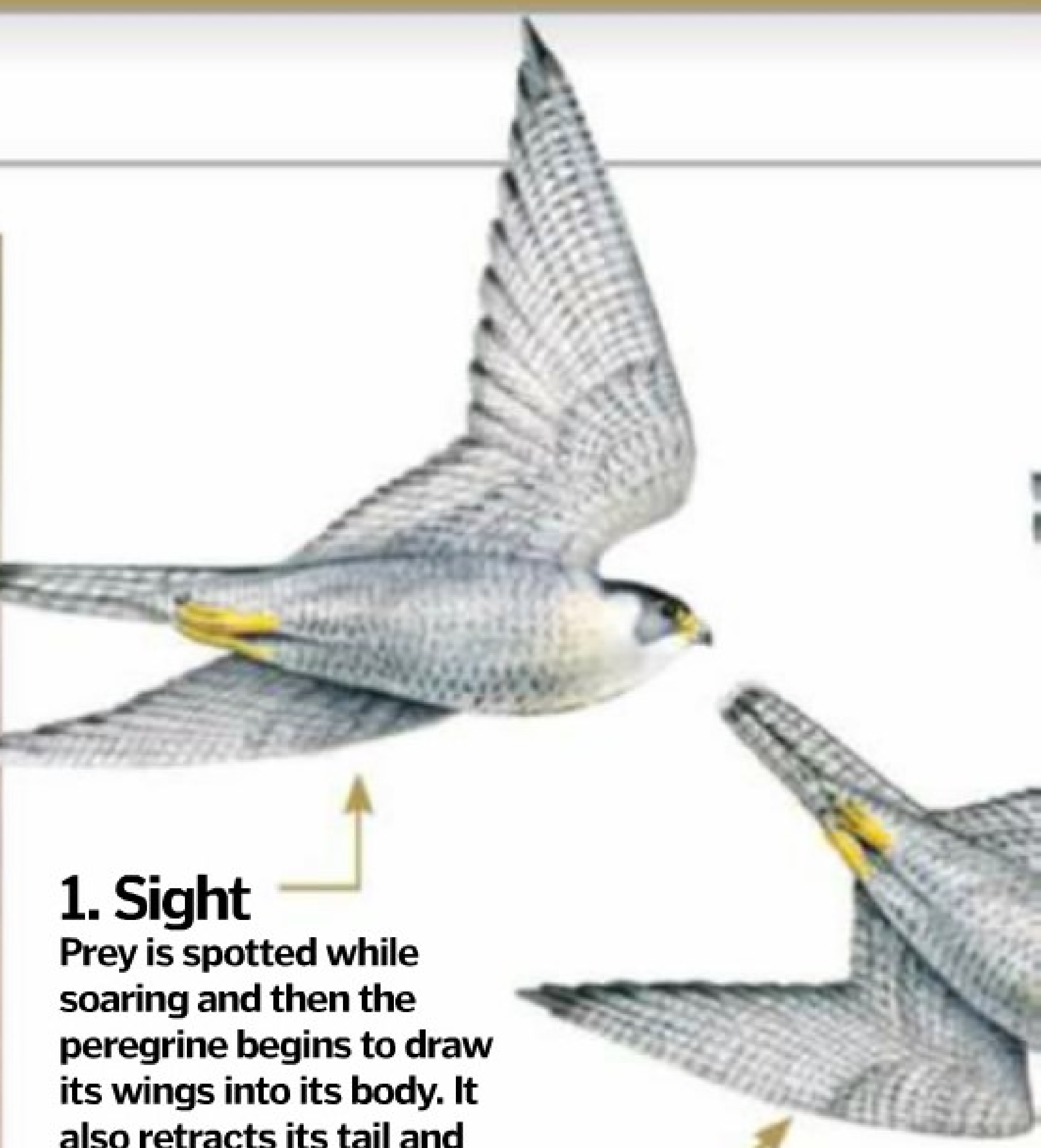
Peregrine falcon

When in free fall, the peregrine falcon is just epically quick

If you thought the cheetah was fast, then think again. The peregrine falcon blows its top speed out of the water by over 130mph. Capable of hitting a monumental 200mph during a stoop (dive), the falcon has the highest top speed of any animal on Earth.

The peregrine's speed is caused by a combination of factors. Firstly it makes use of gravity, diving upon its prey from great height, even when they themselves are airborne. Secondly, its anatomy – as with the cheetah's – has been finely honed to maximise speed, evolving over millions of years into the swift and efficient killer it is today. For example, the peregrine's keel – which is located at its breastbone – is significantly larger than average birds', allowing for bigger muscles and a greater number to attach its wings to its body. This allows it to generate far more power per thrust when building speed. Further, the peregrine's wings have evolved to be incredibly pointed, with slim, stiff and unslotted feathers, which helps streamlining and reducing air resistance significantly.

Unlike the cheetah, however, arguably the peregrine handles its awesome speed much better. Firstly, while having the same enlarged heart and lungs, the peregrine does



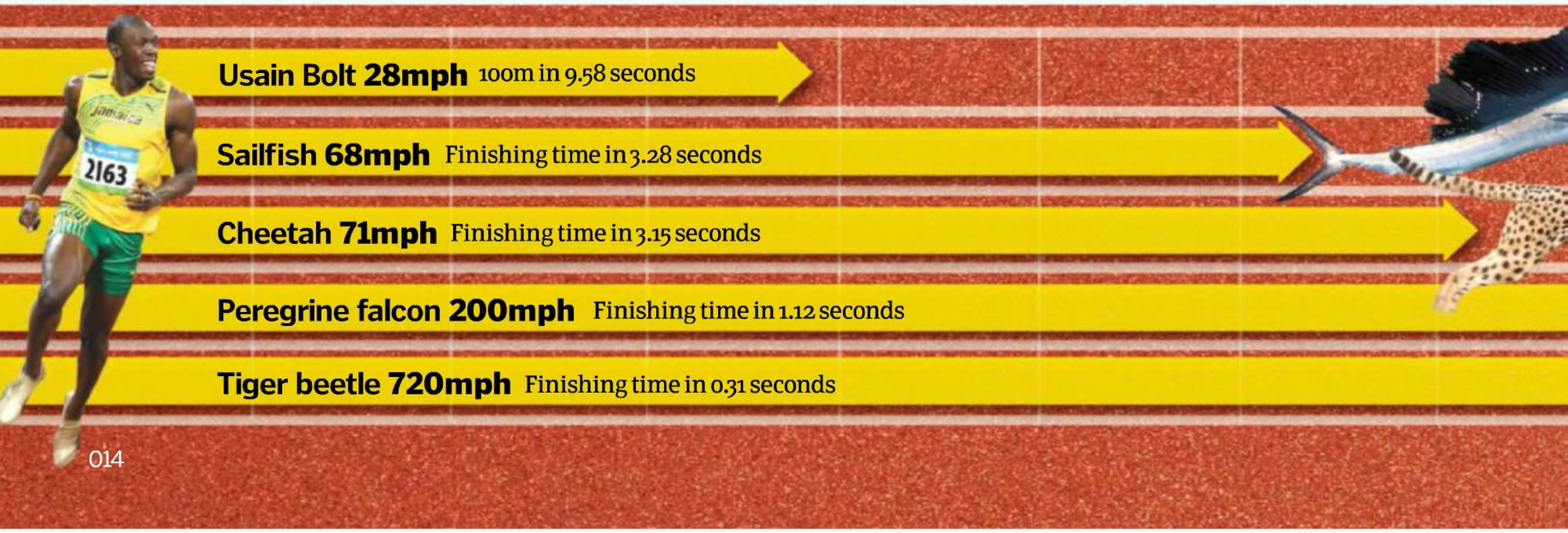
1. Sight
Prey is spotted while soaring and then the peregrine begins to draw its wings into its body. It also retracts its tail and tucks its feet into its body.

2. Streamline
The wings are brought right into the falcon's sternum and – thanks to their pointed, slim, stiff and unslotted feathers – begins to rapidly reduce its air resistance.

3. Velocity
Speed is increased as the falcon bombs down with little-to-zero drag, soon reaching speeds up to 200mph. Its strong keel helps maintain structural solidity during the dive and its eyes are kept clear by nictitating membranes, which act like a third eyelid.

Diving to victory

Check out the four stages a peregrine falcon undertakes to reach 200mph when diving in for a kill



Usain Bolt 28mph 100m in 9.58 seconds

Sailfish 68mph Finishing time in 3.28 seconds

Cheetah 71mph Finishing time in 3.15 seconds

Peregrine falcon 200mph Finishing time in 1.12 seconds

Tiger beetle 720mph Finishing time in 0.31 seconds

Head to Head
SLOWEST ANIMALS

SLOW

© Mfield

1. Galapagos giant tortoise

With a top speed of 0.19mph the Galapagos tortoise is very slow. Luckily, it is protected by a shell to put off predators.

SLOWER

© Ontley

2. Two-toed sloth

With a top speed of just two metres per minute, they are nick-named "bicho-preguiça" in Brazil, which translates as "lazy animal".

SLOWEST

© Geierunited

3. Snail

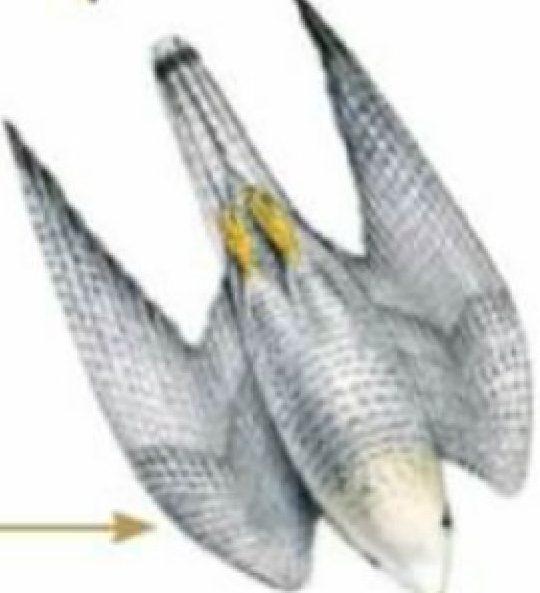
So slow that it was adopted by the Judeo-Christian religion as the physical manifestation of the deadly sin of sloth, the snail takes days to travel mere metres.

DID YOU KNOW? *Usain Bolt currently holds the world 100- and 200-metre records*

The Statistics

Peregrine falcon

Family: Falconidae
Genus: Falco
Weight: 910-1,500 grams
Height: 60cm
Length: 34-58cm
0-60mph: Not recorded
Top speed: 200mph



4. Contact

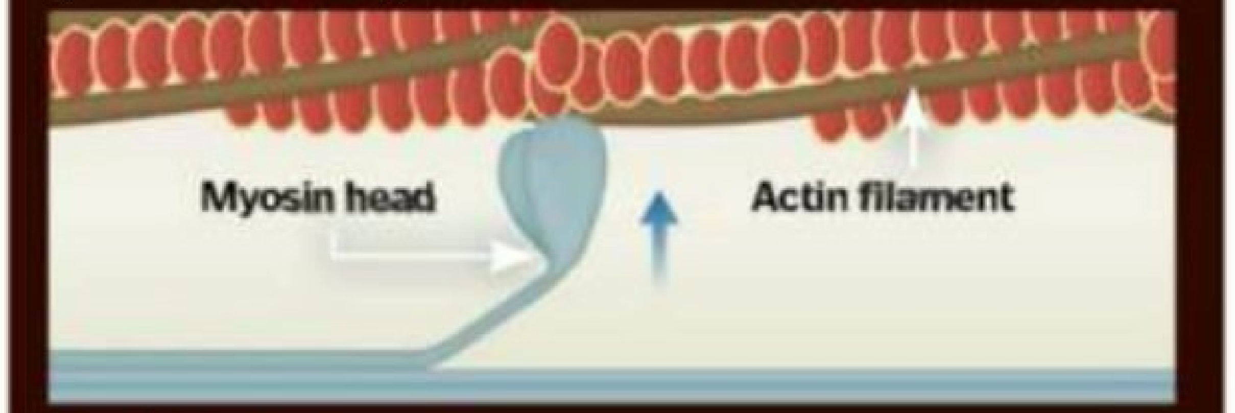
Prey is both struck and captured in mid-air. The peregrine strikes its prey with a clenched foot, which due to the immense speed either stuns or kills it, before then swooping round to catch it with its large claws. Prey is always consumed on the ground.

© DK Images

not suffer damage from oxygen deprivation at the close of its stoop. This is partly due to gravity's beneficial aid in generating its killer speed but also due to the peregrine's ability to absorb oxygen through its red muscle fibres, of which it has many. This allows it to keep a steady oxygen flow at all times and means that, consequentially, it does not need to rest post-kill, reducing its vulnerability to scavengers.

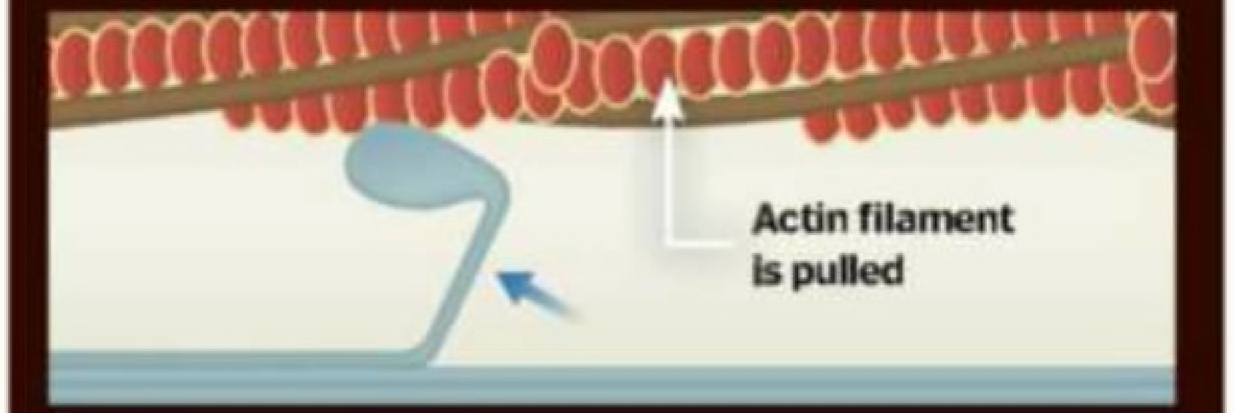
How muscles work – the contraction cycle

Muscle power is common to all these creatures so here's an explanation of how muscles provide the power that in turn provide the speed



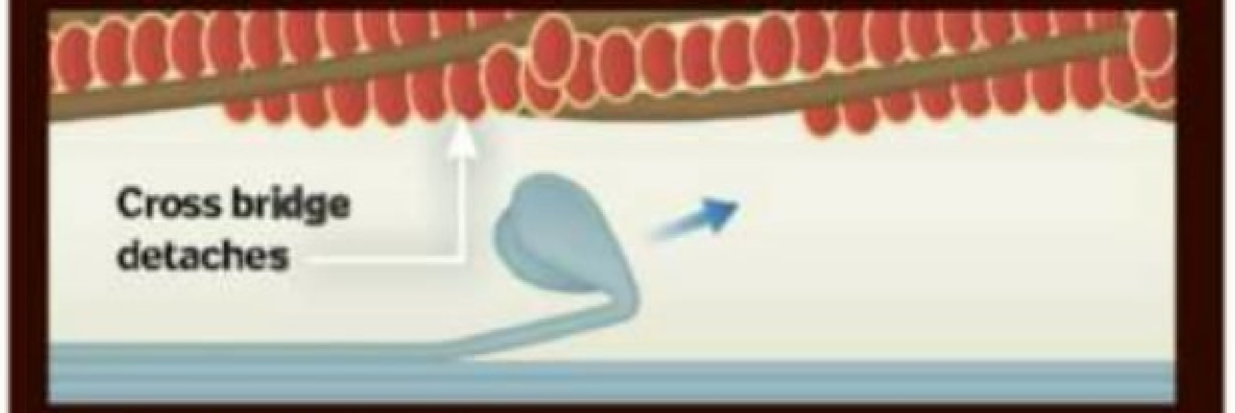
1. Attachment

Firstly a myosin head (akin to an organic hook) attaches itself to an exposed binding site on the muscle filaments, gripping it in a cross bridge.



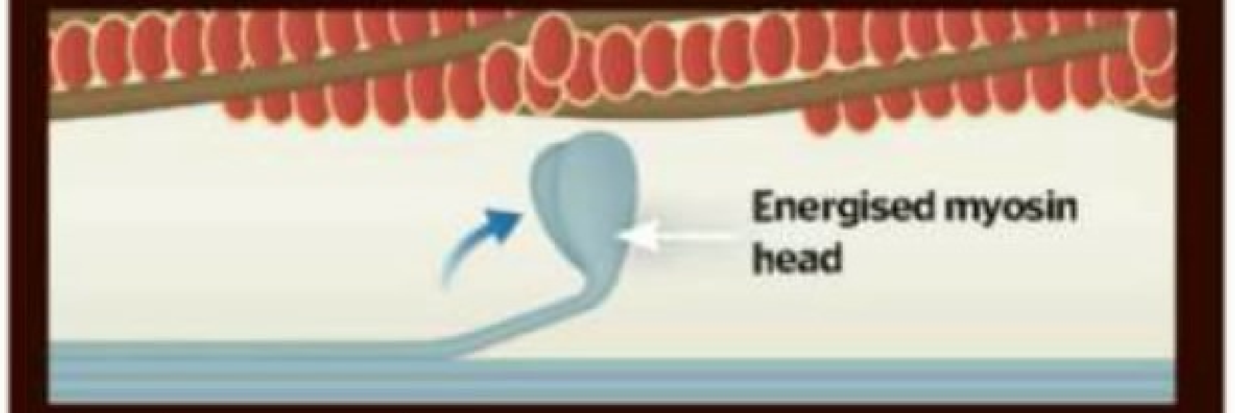
2. Power stroke

The myosin head then pulls the filament by pivoting backwards and dragging it into a compressed position.



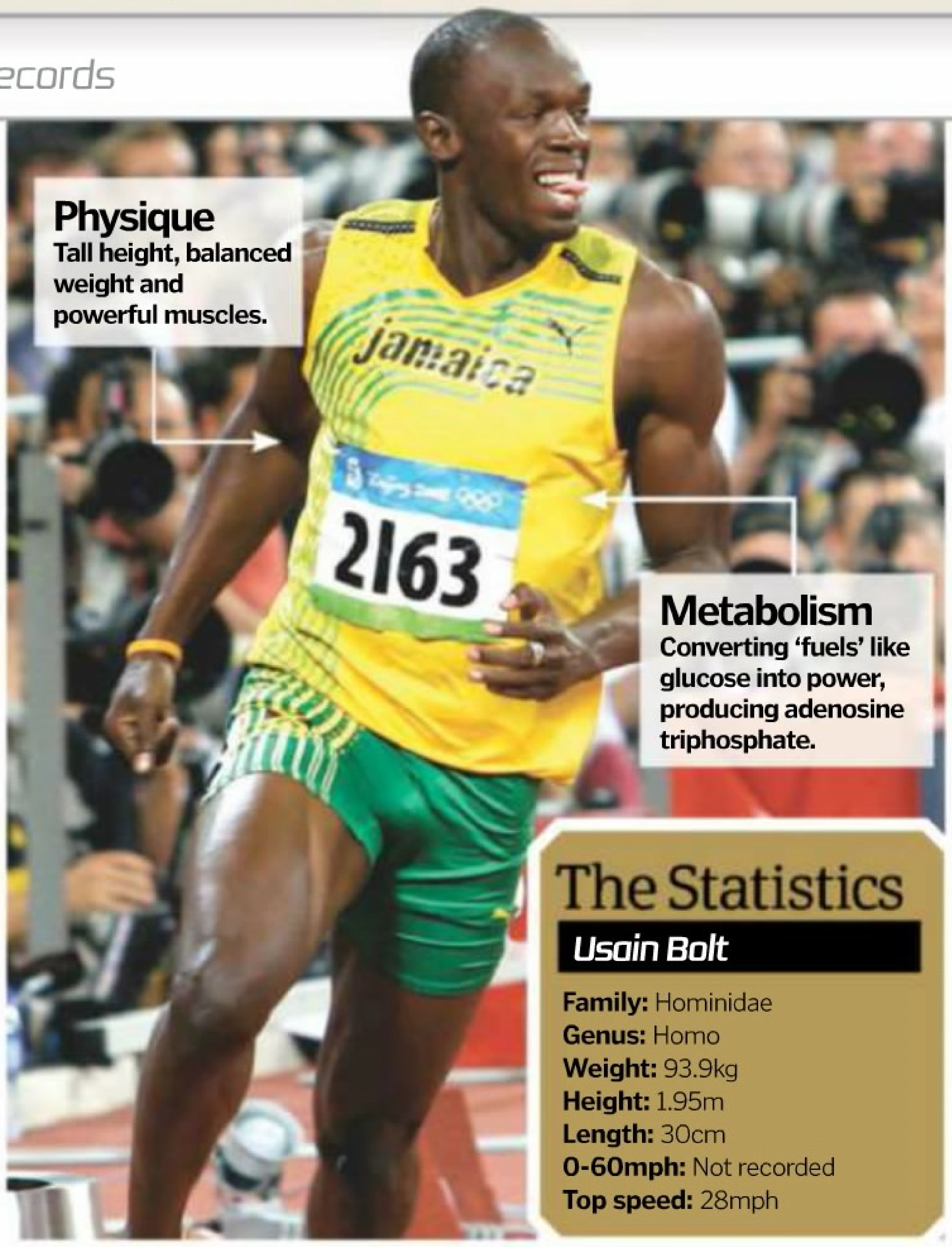
3. Detachment

A molecule of ATP (adenosine triphosphate) then binds to the myosin, releasing its grip of the filament so that the cross bridge detaches.



4. Energy release

Finally, the ATP releases energy to convert the myosin head from its bent, low-energy position back to its initial high-energy configuration ready for the next cycle.



Physique
Tall height, balanced weight and powerful muscles.

Metabolism
Converting 'fuels' like glucose into power, producing adenosine triphosphate.

The Statistics

Usain Bolt

Family: Hominidae
Genus: Homo
Weight: 93.9kg
Height: 1.95m
Length: 30cm
0-60mph: Not recorded
Top speed: 28mph

Usain Bolt

The fastest human alive, Usain Bolt broke the world 100-metre record with a staggeringly quick time of 9.58 seconds

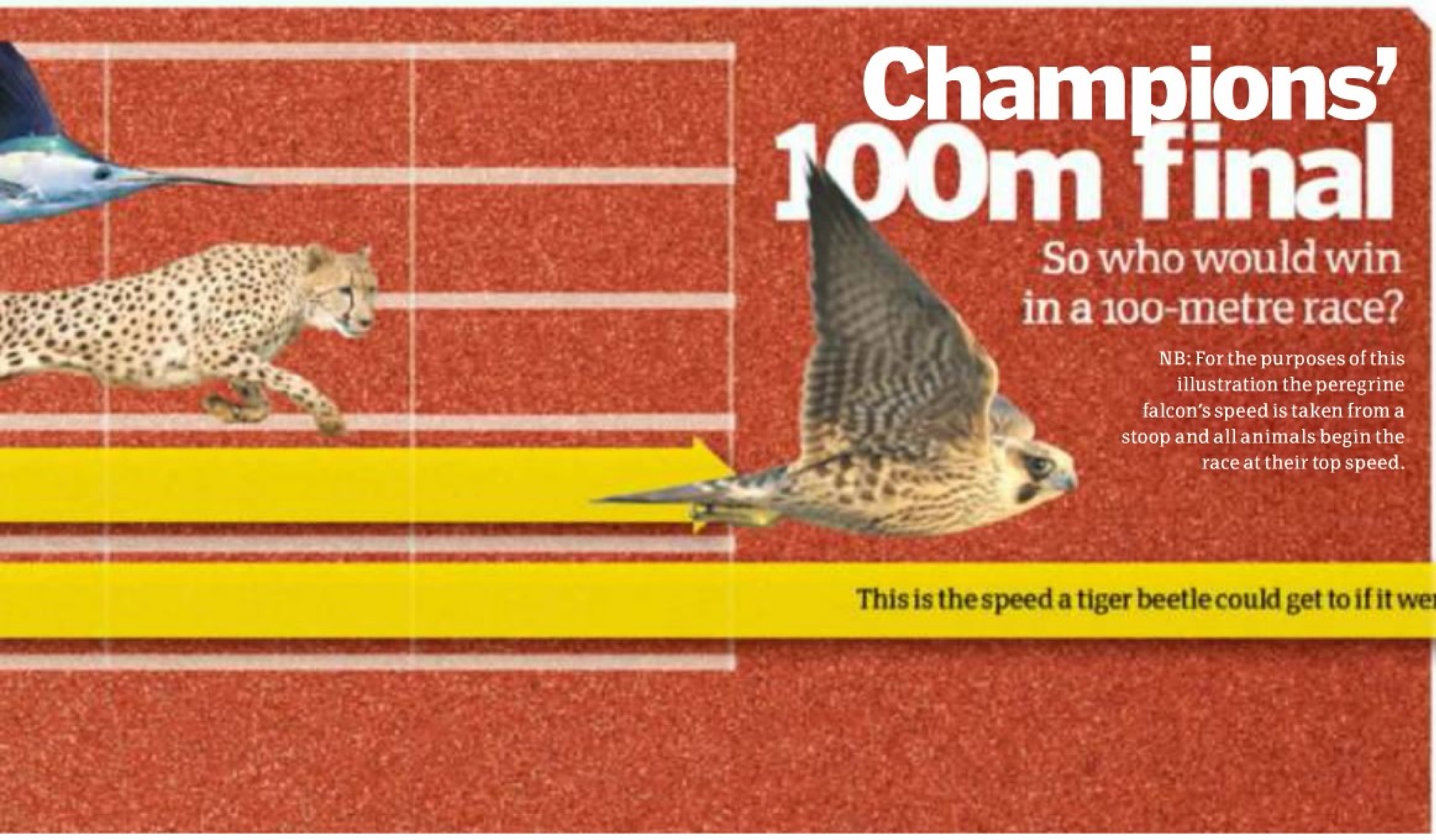
One of the most successful species of animal on the planet, Homo sapiens have evolved over the last 120,000 years into creatures with formidable physical abilities. Currently, the fastest human is Usain Bolt, a Jamaican-born sprinter who has won the world 100- and 200-metre gold medals.

Bolt epitomises the ideal human anatomy needed to produce such high speeds: a tall height (1.95m), balanced weight (93.9kg) and long, powerful muscles with an excellent metabolism – muscles cannot utilise energy-rich "fuels" such as glucose, instead they must convert it into ATP (adenosine triphosphate) with the amount of ATP a muscle produces directly correlating to the amount of power it can generate.

Champions' 100m final

So who would win in a 100-metre race?

NB: For the purposes of this illustration the peregrine falcon's speed is taken from a stoop and all animals begin the race at their top speed.



This is the speed a tiger beetle could get to if it were the same size as an average six-foot man!

The planet's smartest animals

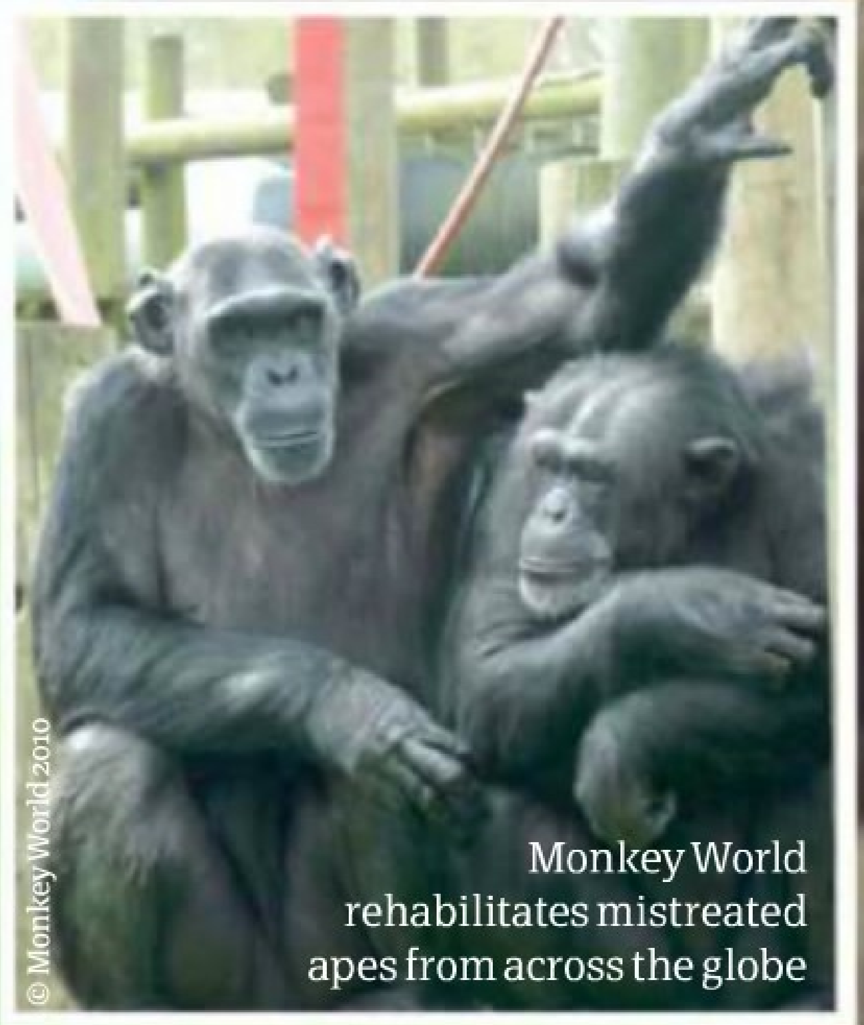
Think your brain separates you from the beasts? The gap is not as wide as you might think…

Humans are intelligent animals. We aren't the strongest, nor the largest, nor the longest lived, but we flatter ourselves that we are the cleverest. In fact, it is so central to our sense of superiority that we assume intelligence automatically improves the survival chances of any animal. But, in fact, there is no good evidence for this. A brain is a very expensive organ to grow and maintain – 20% of the food we eat every day is used just to keep our brain alive – and complex brains take a long time to fill with data before they become useful. Bacteria, plants and fungi have shown vastly more diversity and reproductive success than us without any intelligence at all.

But high intelligence does offer one important advantage: flexibility. Animals with simple nervous systems may be extremely good at what they do, but their behavioural repertoire is hard-coded within an arrangement of neurons that is fixed at birth. New behaviours can only emerge as a result of the painfully slow processes of mutation and natural selection. An intelligent animal is an improviser. New strategies to deal with changing conditions or newly conquered territories can emerge as required and successful techniques can spread through a family group or tribe by observation and imitation over days or weeks, while it would take generations for new genes to spread.

Most mammals are born with brains that are already 90% of their final adult weight. But to allow room for new behaviours, intelligent animals must begin life with brains that are still partially undeveloped. Newborn chimpanzees' brains are 54% of their adult weight; with dolphins it's 42.5% and elephants 35%. So the elephant is the animal that learns most throughout life, after humans, who are born with just 28% of their adult brain mass.

In the *Hitchhiker's Guide To The Galaxy*, Douglas Adams wrote that "Man had always assumed that he was more intelligent than dolphins because he had achieved so much – the wheel, New York, wars and so on – while all the dolphins had ever done was muck about in the water having



Monkey World rehabilitates mistreated apes from across the globe

© Monkey World 2010

Head to Head
Smart species

1. Clever Hans
This horse seemed to answer simple arithmetic questions by stamping his hoof, though it transpired that he was reacting to unconscious cues.

2. Rico
A border collie that was taught at the Max Planck Institute to recognise more than 200 words, and could remember the names of objects weeks later.

3. Washoe
Captured by the US Air Force for the space program, this chimp was raised like a human child and learned 350 words of American sign language.

DID YOU KNOW? *The octopus is deemed intelligent enough to count as an honorary vertebrate under animal cruelty legislation*

To learn more about the rescue and rehabilitation work that goes on at Monkey World visit www.monkeyworld.org.

Category of intelligence: Language, tool use, empathy, deception

Brain size: 420g

a good time. But conversely, the dolphins always believed that they were far more intelligent than man – for precisely the same reasons." This neatly illustrates the problem of studying animal intelligence; we tend to measure it by how closely an animal's behaviour resembles our own. We are gregarious, competitive builders, so relatively solitary, peaceful animals that don't make anything, like whales and giant pandas, get dismissed in favour of more showy animals like chimpanzees and dolphins, which can learn behaviour.

To counter this, there are several traits that researchers look for when assessing the cognitive ability of animals. At the simplest level there are planning and problem-solving tests, such as maze puzzles. Then there is evidence of tool use in the wild. At one time it was believed that humans were the only animals to use tools, but there are now more than a dozen different species that have been observed using sticks, stones and thorns in various ways to hunt for food, swat flies or defend themselves. Even dolphins, which don't have grasping hands or feet, are known to use conical sponges to protect their noses when foraging along the abrasive seabed.

Humans are not the only animals to lie, to cheat, to plan for the future, to appreciate beauty, to make toys or to show self-awareness. The more we learn about animals' behaviour, the more intelligent they seem, as illustrated by our examples of some of the savviest and smartest species out there.

The chimps at Monkey World enjoy clicker training

© Monkey World 2010

Chimpanzees

These primates have an intelligent and self-assured personality

Chimpanzees are our closest living relatives and so their intelligence is the easiest to understand and measure. In the wild, chimpanzees use tools, hunt co-operatively, display signs of mourning, romantic love, appreciation of natural beauty and complex play. Chimpanzees lack the vocal apparatus to manage human speech, but in captivity they have been trained to use and understand American sign language. There is still some scientific debate over whether chimpanzees actually understand the language or are simply responding to cues, but in one study a bonobo chimpanzee called Kanzi was asked a question he had never heard before: "Can you make the dog bite the snake?" Kanzi searched through his toys to find a dog and a snake, placed the snake in the dog's mouth and closed it shut using his finger and thumb.

Chimpanzees have a sense of humour and their own version of laughter (a sort of panting sound); they are ticklish and use tickling in their play. They also use simple dollies, grooming and cuddling sticks or stones as if they were babies.

Intelligence rating: ■■■■■

© Monkey World 2010

INTERVIEW

MONKEY WORLD
APE RESCUE CENTRE

Name: Dr Alison Cronin MBE

Bio: Director, Monkey World – Ape Rescue Centre.
Monkey World was started in 1987 by my late husband, who wanted to provide a home for chimps that had been smuggled from the wild to be used as beach photographers' props in Spain. In the past 24 years the park has assisted the governments of 21 countries to stop the smuggling or abuse of monkeys and apes.

How many chimpanzees are being cared for at Monkey World and where were they rescued?
There are currently 59 chimpanzees at the park that have been rescued from the illegal pet trade, beach photographers, the entertainment industry and laboratories. Monkey World assists governments to stop the smuggling, abuse or neglect of primates. At the park, the refugees of these trades are rehabilitated into natural living family groups.

When have these chimpanzees displayed their intelligence and by what means?
By definition, chimpanzees are intelligent and they also share the full range of emotions that humans experience – grief, fear, excitement, happiness, etc. Understanding the feelings and emotions of others in your community is an important part of life for a chimp, just as it is for humans.

Chimpanzees are very good tool users as they are clever, good at solving problems, have good hand/eye motor skills, and a pretty good precision grip with both their hands and feet. They make and use 'dipping sticks' from leafy branches given to them at the Centre, to fish for insects inside rotten logs in their enclosure or in the mock termite mound placed for them inside their house. The Primate Care Staff give them many types of feeding puzzles to keep them busy and the chimps are also very keen on clicker training games, where they are asked to put their ear up for staff to use an electronic thermometer.

The fact that apes are so clever has led to the abuse of chimps for the illegal tourist entertainment – what's being done to stop this?
The CITES is an international treaty that protects endangered species. Monkey World assists governments in enforcing the treaty by providing the professional support required to 'handle', move and re-home monkeys and apes that have been smuggled into their country. There was a big problem with beach photographers in Spain with baby chimps that had been poached from the wild. With Monkey World's assistance, the trade in Spain has been stopped and the smugglers tracked back to Turkey, where discussions with the Turkish authorities are being conducted. There is also a large black market trade in the Middle East, and Egypt in particular.

What other apes at the rescue centre display the most intelligence?
By far the most intelligent of all are the orangutans. They are focused and thoughtful and always a challenge to keep busy and occupied.

Category of intelligence: Navigation

Brain size: 0.1g per bee, 3,000g for a hive

Honeybees work together cleverly as a collective group

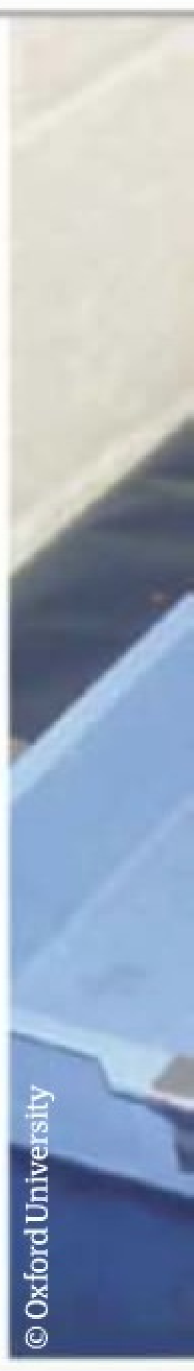
2 x © Macro Freak 2007

Honeybees

Show me the honey

Honeybees are highly social insects, with colonies of 30,000 or more. A single honeybee only has about 950,000 neurons in its brain, but if you consider the whole hive as a single diffuse entity, it has almost 3 billion to play with. The human brain only has 10 billion neurons. Honeybees returning to the hive use a special waggling dance to communicate their discoveries to other workers, and the colony uses a kind of democratic consensus to choose foraging locations and find a new site for the hive at swarming time. Studies show that this method consistently allocates workers in the most efficient way. Bees can also maintain a map of their surroundings in their head and will take the shortest route between multiple sites.

Intelligence rating: ■■■□□



© Oxford University

Category of intelligence: Deception

Brain size: 6g

Not forgetful, just sneaky!

Grey squirrels

More than just nuts

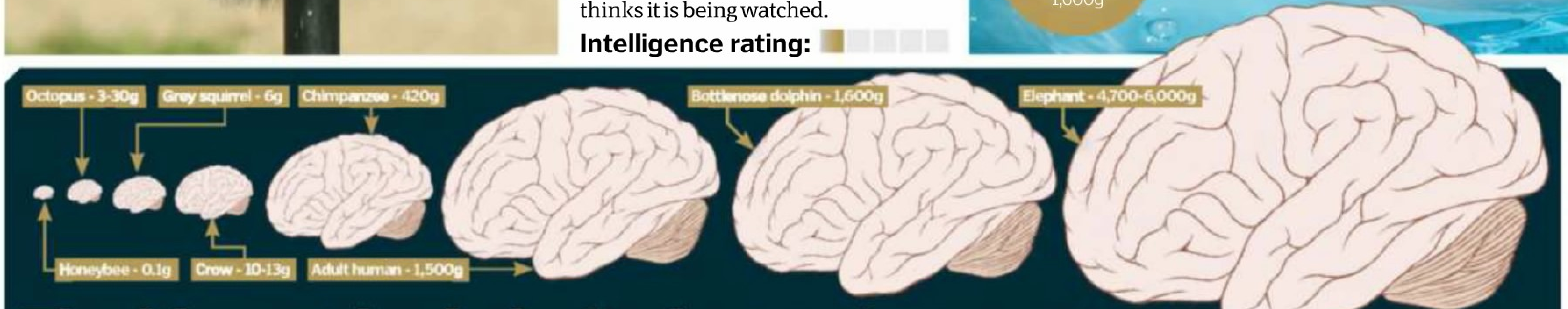
Squirrels have a reputation for being rather dizzy – burying nuts and acorns at random and promptly forgetting where. It turns out that this is just a front. The biggest threat to a squirrel is from other squirrels stealing their caches, so they make a big show of pretending to bury non-existent nuts to fool would-be thieves. Studies have shown that the proportion of fake burials increases when the squirrel thinks it is being watched.

Intelligence rating: ■□□□□

Purposeful porpoises...

Category of intelligence: Play

Brain size: 1,600g

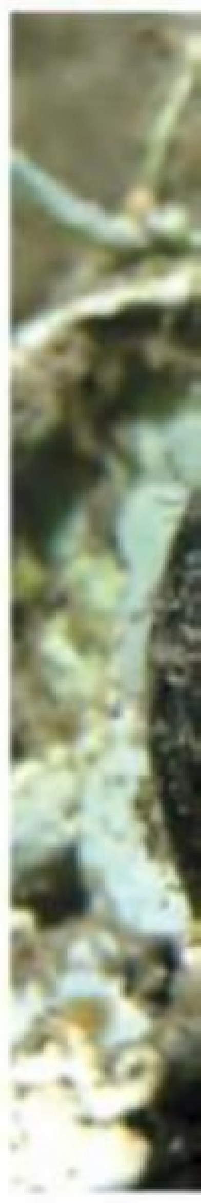


The biggest brain isn't always the smartest

Brains are not the same thing as intelligence. In any animal, most of the neurons in the brain are taken up with controlling the muscles and collecting sensory information from all the nerve endings in the body. So a larger body requires a larger brain, simply to co-ordinate its movement and operate the basic metabolism. Broadly speaking, the size of an animal's brain rises with the two-thirds power of body weight. So doubling body weight increases brain weight by 1.6 times.

Animals with brains larger than this formula would predict might be assumed to have brain tissue 'left over' that is available for more complex reasoning. This includes whales, dolphins, elephants and primates. But there are problems with this. The animal with the highest ratio of brain size to body size is the African tree shrew, and it may be that disproportionately large brains are used for other things besides intelligence, such as a highly developed sense of smell.

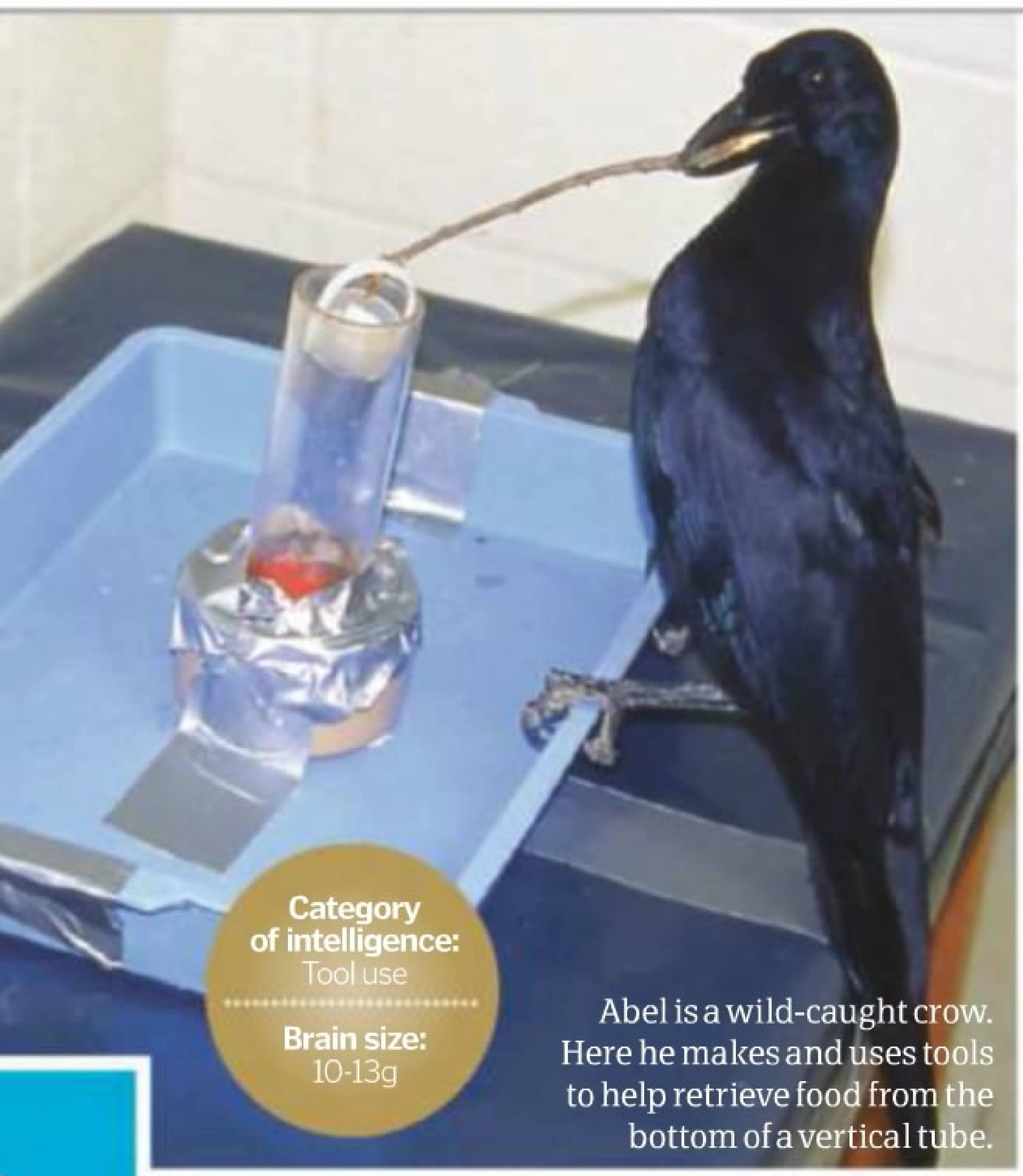
Brain image © Patrick J Lynch



Elephant doctors

Pregnant African elephants will walk for miles to find wild herbs from the borage family. Chewing these releases a drug that helps to induce labour. Kenyans also use the plant for this purpose – a trick they learned from the elephant.

DID YOU KNOW? *Sperm whales have the largest brain of any animal that has ever lived. A typical male's brain weighs 7.8kg (17.2lb)*



Category of intelligence: Tool use

Brain size: 10-13g

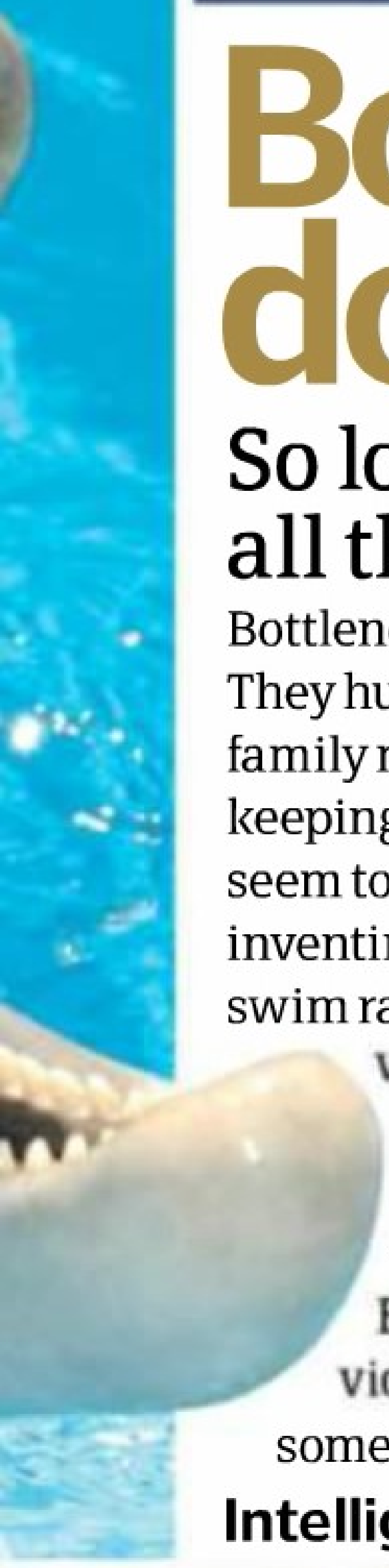
Abel is a wild-caught crow. Here he makes and uses tools to help retrieve food from the bottom of a vertical tube.

Crows

Plenty to crow about

Crows are the most intelligent birds. The New Caledonian crow can fashion a variety of tools by plucking and bending grass stems and twigs and use them to extract grubs and insects from their nests. In the lab, they will bend wire to form a hook to extract a reward from a narrow jar. The hooded crow uses scavenged breadcrumbs as bait to catch fish. Crows in Japan will drop nuts onto busy streets so that passing cars will crack the shells and then patiently wait at the crossing for the lights to turn red, so they can retrieve them.

Intelligence rating: ■■□□□

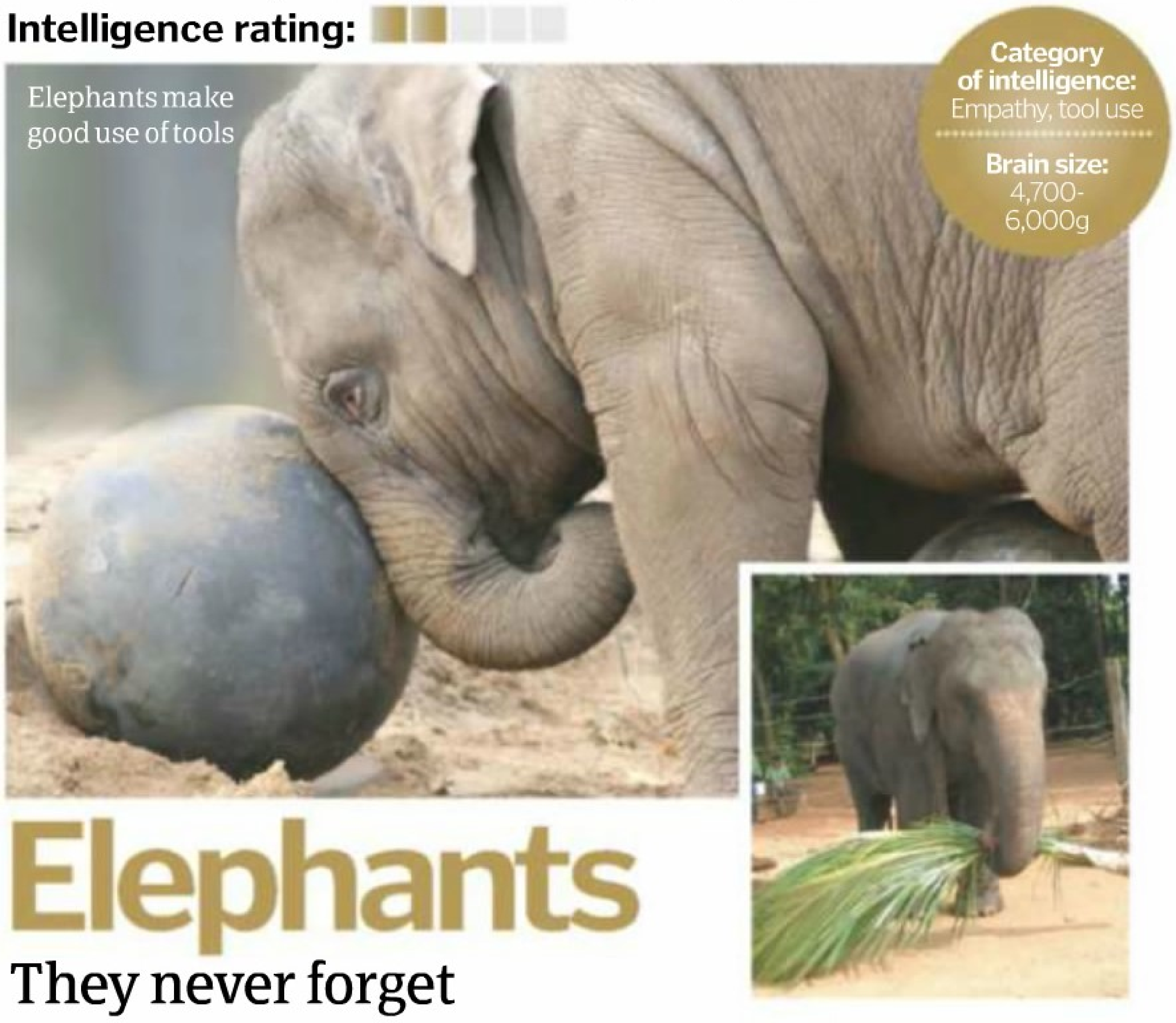


Bottlenose dolphins

So long, and thanks for all the fish…

Bottlenose dolphins have larger brains than us. They hunt co-operatively and will assist injured family members or even human swimmers by keeping them close to the surface. Dolphins also seem to devote much of their intelligence to inventing complex games. For example, they will swim rapidly in a circle and then blow air into the vortex created, so the bubble forms a doughnut shape. Sometimes they will admire their creation, other times they will chase it as it rises and bite it. Experiments using mirrors and playing video footage back to dolphins have shown some evidence that they may also be self-aware.

Intelligence rating: ■■■■□



Elephants make good use of tools

Category of intelligence: Empathy, tool use

Brain size: 4,700-6,000g

Elephants

They never forget

The elephant is obviously a very large animal, so you would expect it to have a large brain. But the structure of an elephant's brain is more surprising. The neocortex is as complex and has as many neurons as the neocortex of the human brain. This part of the brain is believed to be associated with intelligence and problem solving. Elephants also have the largest hippocampus of any animal, including humans. The hippocampus is involved in the processing of memory and emotion. Elephants belong to very close-knit societies and have been observed burying their dead and standing over the grave, as if in mourning. They also make extensive use of tools to swat flies and will cover small watering holes with bark and sand to reduce evaporation.

Intelligence rating: ■■■■□

Category of intelligence: Learning, tool use

Brain size: 3-30g

©Nick Hobgood 2006

Octopuses

A brain in every arm

Octopuses only live a few years and have no contact with their parents, so they have to learn fast and teach themselves. They are the most intelligent invertebrate organisms, and studies have shown that they can solve mazes and be taught to unscrew jar lids. The nervous system of an octopus is quite decentralised: two-thirds of its neurons are in the tentacles, allowing them to behave semi-independently. The veined octopus will pick up coconut shells and use them to build a protective shelter. This makes it the only invertebrate to use tools. Octopuses also engage in play, catching and releasing objects caught in circular currents.

Intelligence rating: ■□□□□

TEN MORE CLEVER CRITTERS

Some more that you did (and didn't) expect to be included in the brainy bunch…

DOG

Eager to please and easy to train to perform a wide range of different tasks.

CAT

Much more independent than dogs, but with a strong sense of play.

PIG

Can learn what a mirror's image represents and use it to obtain information.

RAT

Exhibits 'metacognition' – making decisions based on whether it thinks it will be able to solve a puzzle.

PARROT

Can mimic human speech and even associate some words with their meanings.

WHALE

Whale brains contain spindle cells, previously only discovered in the great apes, elephants and humans.

ORANGUTAN

Uses leaves to make loud squeaking sounds and tools to extract seeds from fruit.

PIGEON

Can remember hundreds of different images for several years at a time.

ANT

Experienced foragers act as mentors to newcomers, so the nest quickly learns about food sources.

COW

Forms friendship groups within the herd and holds grudges for months or years.

DEADLY VENOM

It's the tiniest bite that does the most damage. Find out how these poisonous predators bring pain and paralysis on their prey

Venom is a force multiplier. It allows small animals to tackle prey that approach or even exceed their own body size. Killing your prey with brute strength alone requires a large body, which in turn means that you need to catch more food to sustain it. Venom enables a predator to make a single strike from ambush and completely incapacitate its victim in less than five seconds. This is much more energy efficient than a prolonged tussle and eliminates the risk of injury to the predator.

Most venom is secreted by modified salivary glands. Ordinary saliva already contains digestive enzymes to begin breaking down food before it reaches the stomach. Venom probably first evolved in animals that killed their prey with a bite and then injected saliva to 'marinade' the meat so that it was easier to consume. After that, natural selection would favour those animals with evermore potent combinations of enzymes until the saliva itself did enough damage to kill the prey. Modern venom is often a cocktail of hundreds of different enzymes and peptides. As well as digestive enzymes, most species also include specific compounds that block the transmission of nerve impulses; this causes paralysis and suffocation.

Of course, while venomous animals are continuously evolving new toxins, their prey are also frantically evolving venom resistance. To counter this, most animals inject vastly more than the minimum lethal dose of venom with each bite. This guarantees the kill and also hastens it, which stops the victim from escaping to die alone, or injuring the predator.

Venom is less effective against large animals because of the time it takes to spread through the body, so larger animals are less likely to be venomous. The main exception to this is snakes, which use venom to compensate for their lack of claws to hold struggling prey in place. There are about 650 venomous species of snake but only a few venomous lizards.

DEADLY FACTOR

Brazilian wandering spider

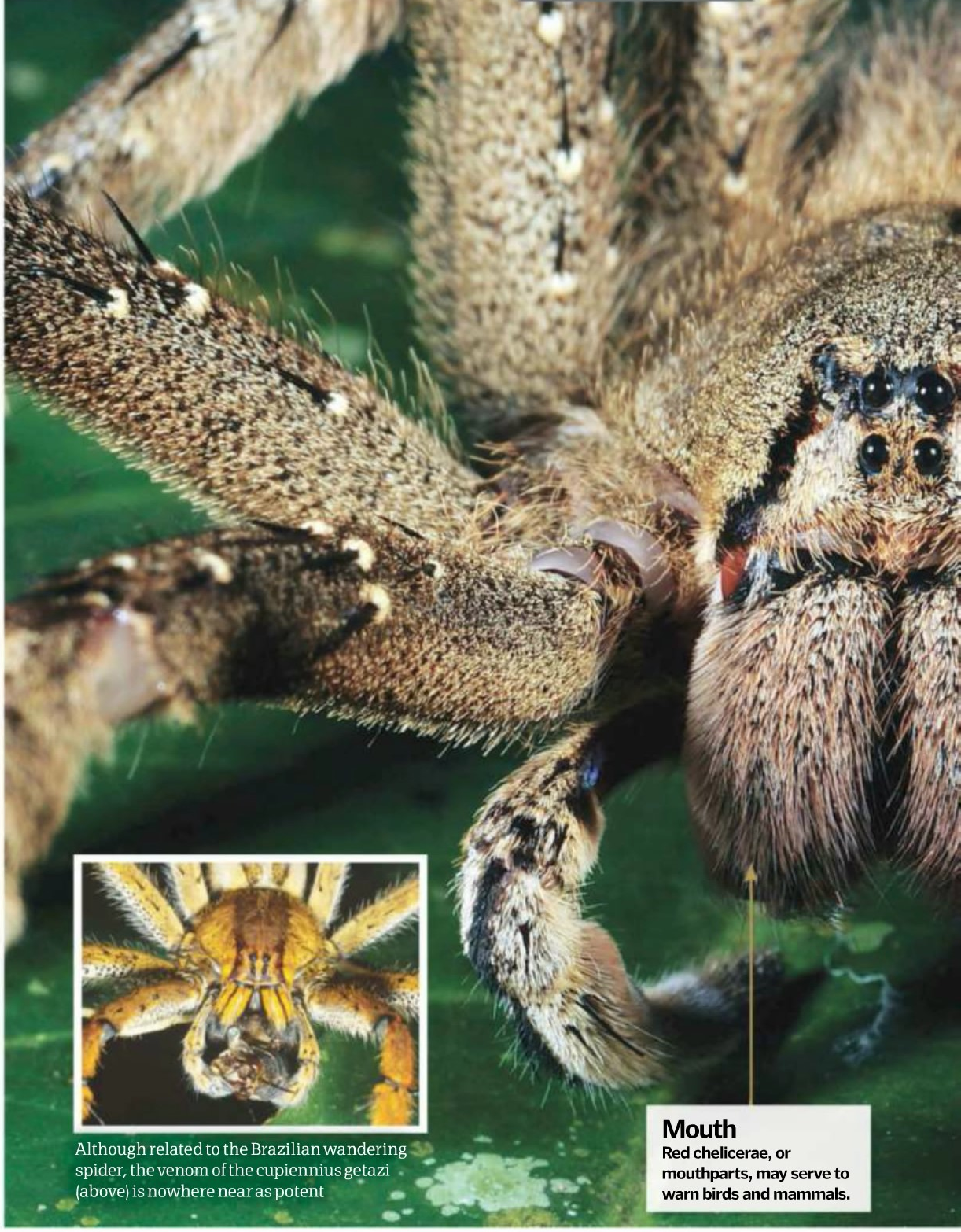
AGGRESSION: High. Often hides in houses and bites when cornered.

INTELLIGENCE: Limited. A deadly, instinctive assassin.

SPEED: High. A speedy scuttler that jumps when it strikes.

STRENGTH: Low. But the fangs will puncture skin and clothes.

DEADLY RATING: ☠ ☠ ☠ ☠ ☠


Mouth
Red chelicerae, or mouthparts, may serve to warn birds and mammals.

Although related to the Brazilian wandering spider, the venom of the cupiennius getazi (above) is nowhere near as potent

DEADLY

© Aloazia

1. Yellow-bellied sea snake

This marine serpent has a venom more toxic than any land snake, which causes muscle breakdown, renal failure and cardiac arrest.

DEADLIER

2. Lonomia moth caterpillar

The spines of this bug inject a powerful anticoagulant. Brushing past a group of them can cause inner haemorrhaging as well as kidney failure.

DEADLIEST

© Mithril

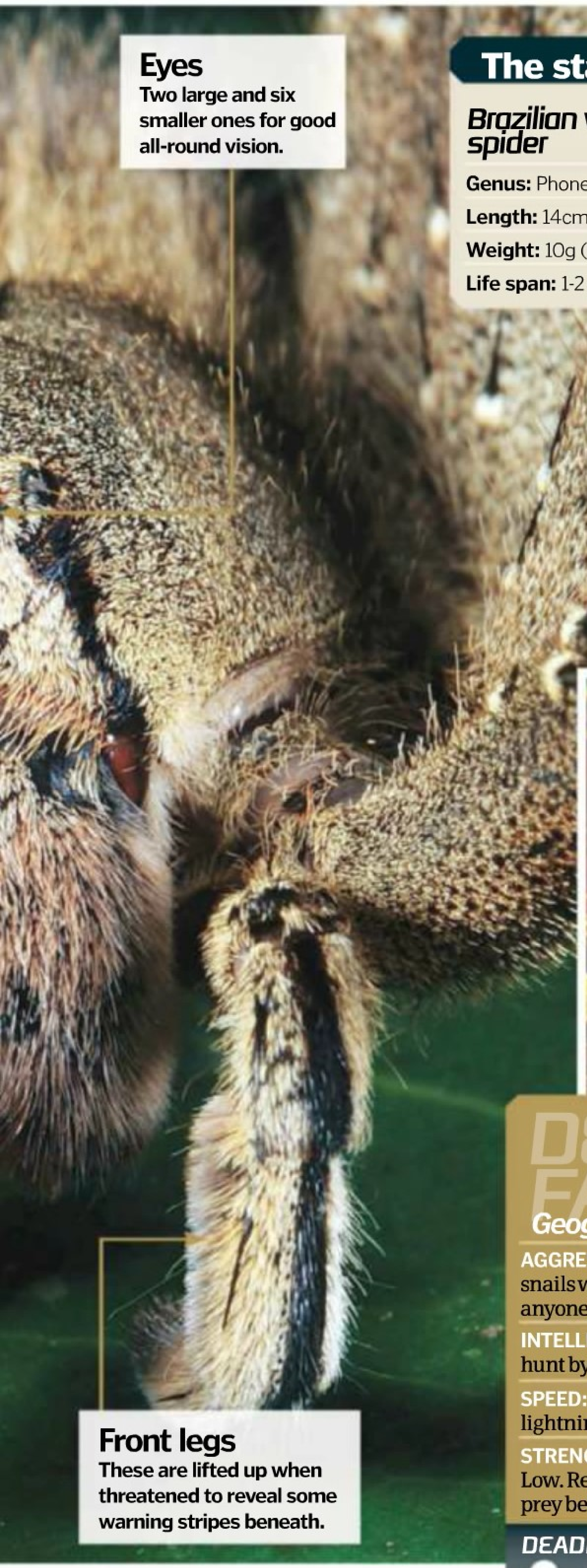
3. Box jellyfish

Virtually transparent and carrying around half a million stingers per tentacle, the box jellyfish is one of the deadliest creatures in the sea.

DID YOU KNOW? *Although the inland taipan is the world's most venomous snake, there's no recorded case of a human fatality*

BRAZILIAN WANDERING SPIDER

Wandering spiders do not spin webs. They stalk the forest floor at night and attack anything they come across, from insects to mice. In the day they hide somewhere dark and moist and this can bring them into contact with humans as they are often found near houses or in bunches of bananas. The Brazilian wandering spider has the deadliest venom of any spider – a neurotoxin two to five times more toxic than the black widow's. The relatively low fatality rate of victims is thought to be partly because the spider will often 'dry bite' to conserve venom. Bites cause instant, intense local pain and swelling, followed by irregular heart rhythm, vomiting and internal haemorrhaging.



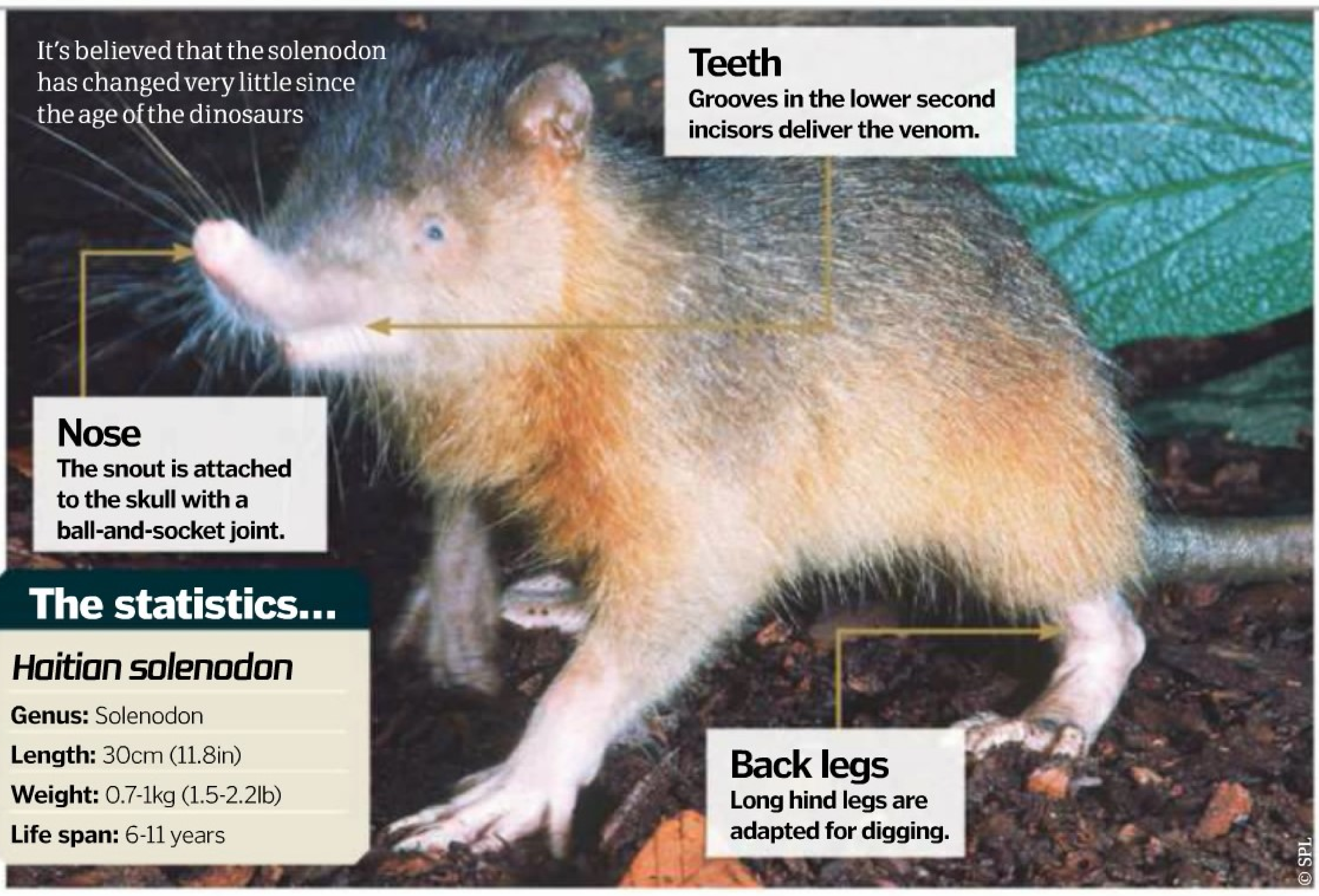
Eyes
Two large and six smaller ones for good all-round vision.

Front legs
These are lifted up when threatened to reveal some warning stripes beneath.

The statistics...

Brazilian wandering spider

Genus: Phoneutria
Length: 14cm (5.5in)
Weight: 10g (0.35oz)
Life span: 1-2 years



It's believed that the solenodon has changed very little since the age of the dinosaurs

Teeth
Grooves in the lower second incisors deliver the venom.

Nose
The snout is attached to the skull with a ball-and-socket joint.

Back legs
Long hind legs are adapted for digging.

© SPL

The statistics...

Haitian solenodon

Genus: Solenodon
Length: 30cm (11.8in)
Weight: 0.7-1kg (1.5-2.2lb)
Life span: 6-11 years

HAITIAN SOLENODON

Solenodons are related to the shrew but much larger – about the size of a hedgehog. The word solenodon means 'slotted tooth' in Greek and these slots, or grooves, are used to inject the venomous saliva into their prey. They evolved on the islands of the Caribbean, without any natural predators. The introduction of cats and dogs has left them extinct everywhere except for Cuba and Hispaniola. The Haitian, or Hispaniolan, solenodon is the more aggressive of the two and will attack without provocation. In the wild they eat earthworms and insects, as well as the occasional frog or lizard. Their venom is not lethal to humans but, in smaller animals, it causes paralysis, convulsions, bulging eyeballs and death. Interestingly, solenodons aren't immune to their own venom.

DEADLY FACTOR

Haitian solenodon

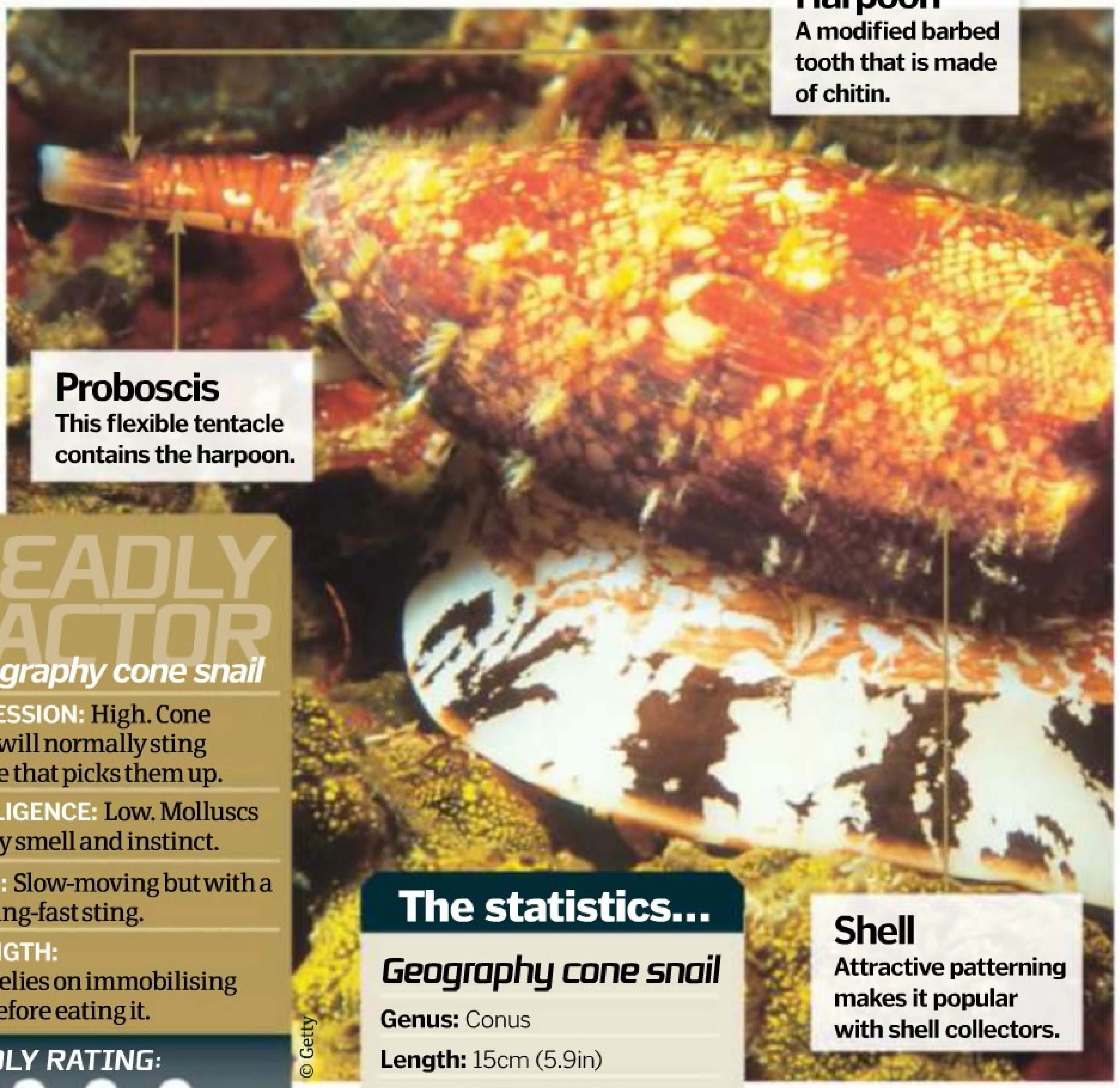
AGGRESSION:
High. Evolved without natural predators and shows no fear.

INTELLIGENCE:
A mammal's brain makes this one shrewd shrew.

SPEED: Slow. Solenodons run in an awkward zigzag pattern.

STRENGTH: High. Solenodons have been known to tear a chicken to pieces.

DEADLY RATING:
☠☠



Harpoon
A modified barbed tooth that is made of chitin.

Proboscis
This flexible tentacle contains the harpoon.

Shell
Attractive patterning makes it popular with shell collectors.

© Getty

DEADLY FACTOR

Geography cone snail

AGGRESSION: High. Cone snails will normally sting anyone that picks them up.

INTELLIGENCE: Low. Molluscs hunt by smell and instinct.

SPEED: Slow-moving but with a lightning-fast sting.

STRENGTH:
Low. Relies on immobilising prey before eating it.

DEADLY RATING:
☠☠☠☠

The statistics...

Geography cone snail

Genus: Conus
Length: 15cm (5.9in)
Weight: 300g (10.6oz)
Life span: Unknown

GEOGRAPHY CONE SNAIL

There are over 600 species of cone snail and all of them are venomous. Cone snails deliver their venom using a thin harpoon made from a modified tooth. This is fired from a flexible proboscis that enables the snail to fire in any direction, even directly behind it; this means that there is no safe way to pick up this gastropod. The venom of the cone snail contains over 200 different compounds that can paralyse a small fish in less than two seconds. The geography cone is a particularly large and venomous species. It can deliver enough venom to kill 15 humans in a single sting. There is no antidote; medical care consists of just treating the symptoms until the venom is metabolised.

THE ODD ONE OUT

Which of these is venomous?

BLUE POISON ARROW FROG

The bright colours warn of the deadly toxins in its skin. The most toxic species can kill a human after one brief touch.

SLOW LORIS

This sleepy creature has a special gland on each arm that it licks to give itself a toxic bite. Mothers also lick the fur of their young to deter predators.

© Dr Philip Bethge

DUCK-BILLED PLATYPUS

The male platypus has a sharp spur on its hind legs. The venom isn't powerful enough to kill a human but it can cause excruciating pain.

© Nigel Voaden

HOODED PITOHUI

Its diet of beetles provides a supply of the neurotoxin homobatrachotoxin. This chemical seeps into the feathers and just touching the bird can cause numbness.

ANSWER: THEY ALL ARE!

BLUE-RINGED OCTOPUS

Although one of the smallest octopuses this is easily the most lethal. The main ingredient in its venom is tetrodotoxin, which is 10,000 times more toxic than cyanide. Tetrodotoxin is found in many other venomous animals, including cone snails, but it's present in much higher concentrations in blue-ringed octopus venom. Bites are tiny and almost painless but, within ten minutes, the venom blocks the action of all the nerves that control the muscles. General paralysis and breathing difficulty ensue, but because the venom can't cross the blood-brain barrier, the victim remains aware throughout. The paralysis even results in fixed, dilated pupils and rescuers may give up resuscitation attempts while the victim is still alive and conscious.

DEADLY FACTOR

Blue-ringed octopus

AGGRESSION: Docile. Will only attack if provoked or stepped on.

INTELLIGENCE: High. Can solve mazes and imitate its surroundings.

SPEED: Moderate. Uses jet propulsion for extra speed when making a getaway.

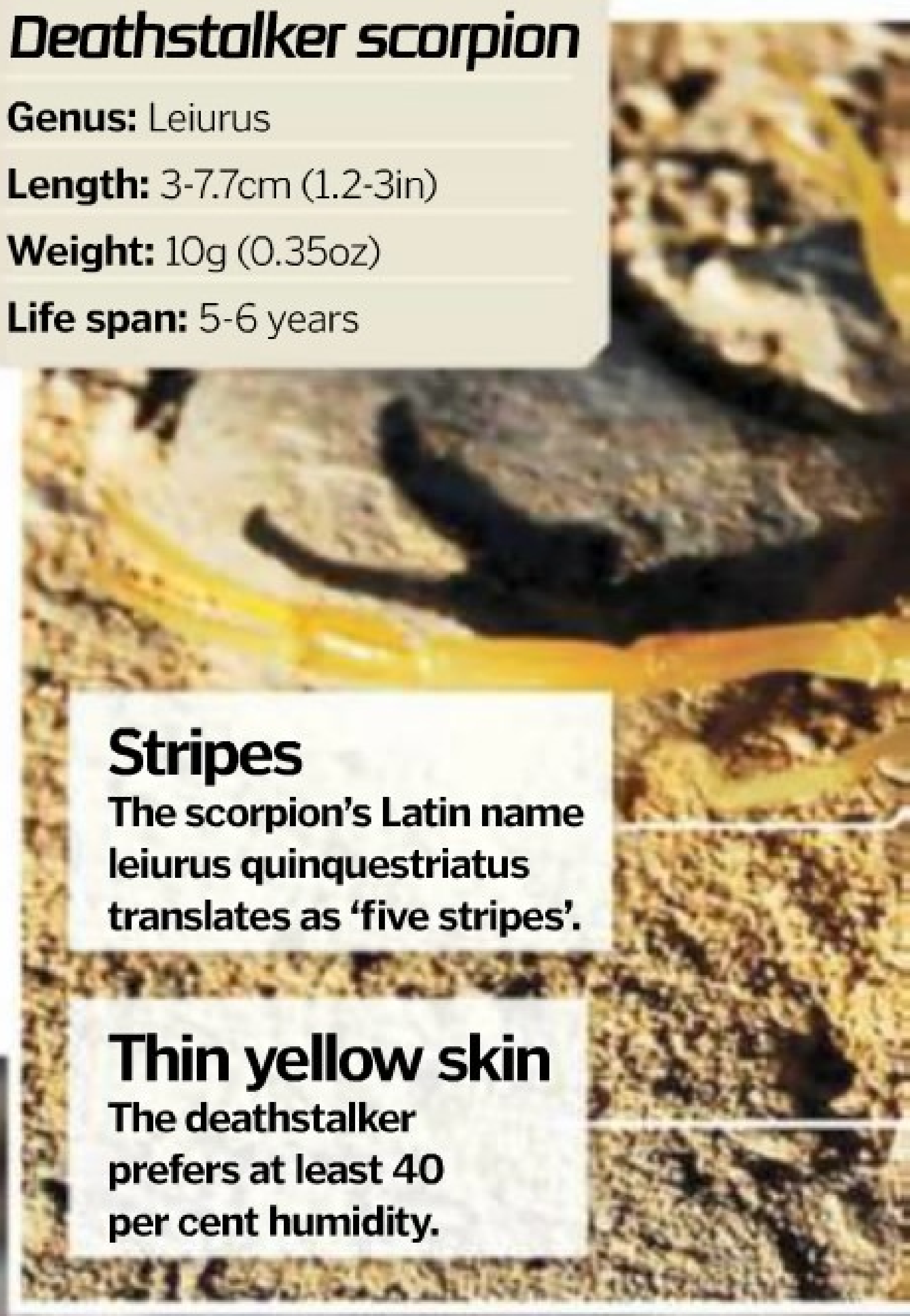
STRENGTH: Moderate. Powerful, muscular tentacles but small overall size.

DEADLY RATING: ☠☠☠☠☠

The statistics...

Deathstalker scorpion

Genus: Leiurus
Length: 3-7.7cm (1.2-3in)
Weight: 10g (0.35oz)
Life span: 5-6 years



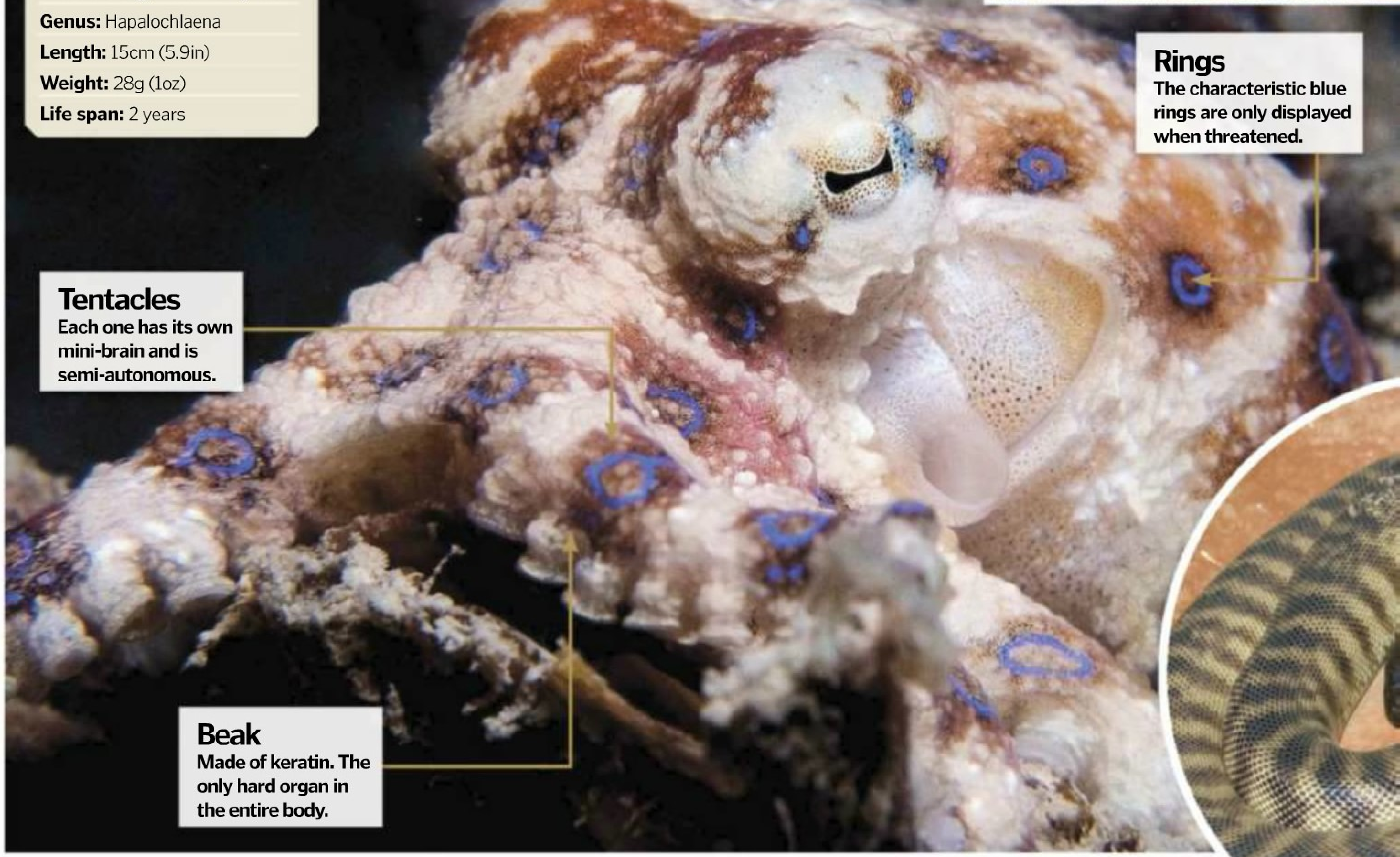
Stripes
The scorpion's Latin name leiurus quinquestriatus translates as 'five stripes'.

Thin yellow skin
The deathstalker prefers at least 40 per cent humidity.

The statistics...

Blue-ringed octopus

Genus: Hapalochlaena
Length: 15cm (5.9in)
Weight: 28g (1oz)
Life span: 2 years



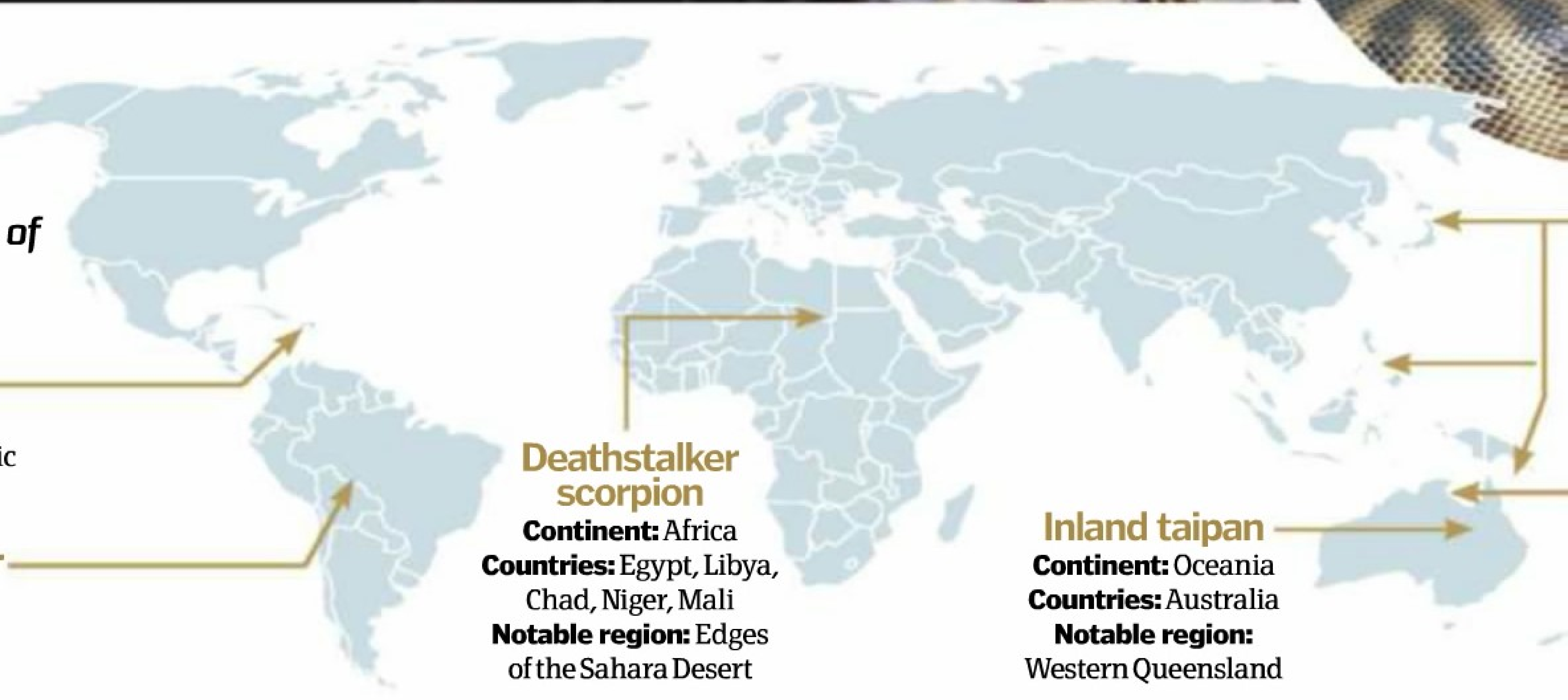
Rings
The characteristic blue rings are only displayed when threatened.

Tentacles
Each one has its own mini-brain and is semi-autonomous.

Beak
Made of keratin. The only hard organ in the entire body.

DANGER MAP

We pinpoint the home turf of some of the toxic beasties featured in this article



Haitian solenodon
Continent: North America
Countries: Haiti, Dominican Republic
Notable region: Hispaniola

Brazilian wandering spider
Continent: South America
Countries: Costa Rica to Argentina
Notable region: Brazilian Amazon

Deathstalker scorpion
Continent: Africa
Countries: Egypt, Libya, Chad, Niger, Mali
Notable region: Edges of the Sahara Desert

Inland taipan
Continent: Oceania
Countries: Australia
Notable region: Western Queensland

5 TOP FACTS VENOM

Different strokes

1 Bees and wasps look similar but strike in different ways. Bee venom is acidic, to cause pain and drive attackers away. Parasitic wasps, meanwhile, use a neurotoxin to paralyse their host.

Small but deadly

2 Baby inland taipans are actually more lethal than adults as they haven't yet learned to regulate their venom dose so will inject their entire supply with a single bite.

Painless stinger

3 Cone shell toxin contains a compound that is 100-1,000 times more effective than morphine as an anaesthetic. This helps to calm prey so they don't struggle too much.

Poisoner by proxy

4 The blue-ringed octopus doesn't even need to bite to poison you; the venom can be absorbed directly through the skin so even swimming near one can result in mild symptoms.

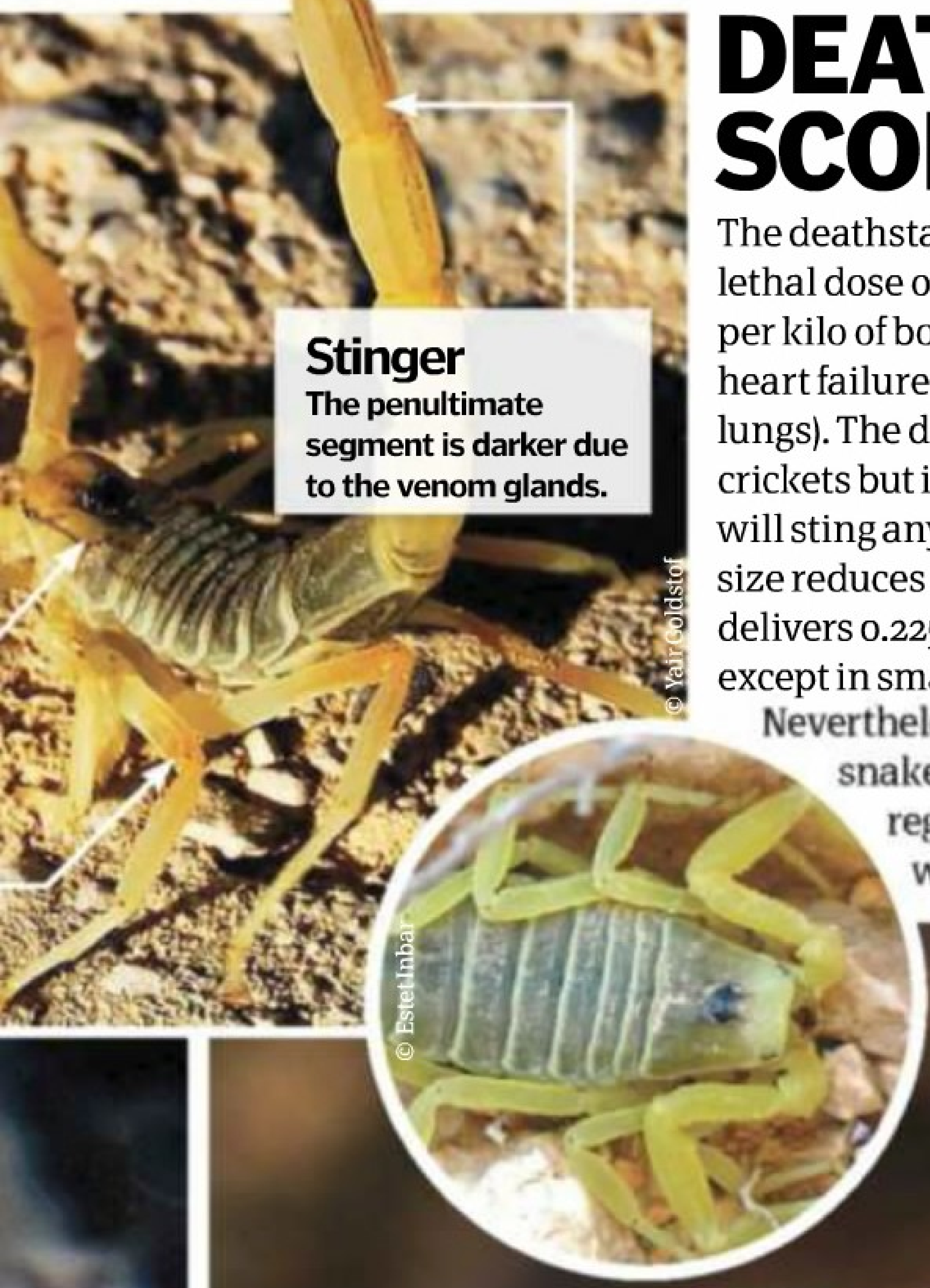
Stiff medicine

5 One unusual side-effect of a bite from the Brazilian wandering spider is that the venom causes acute and painful erections in men that can last for hours.

DI U KNOW? *In 2005, a chef in Somerset, UK, bitten by a Brazilian wandering spider, only survived after a week in hospital*

DEATHSTALKER SCORPION

The deathstalker is the most venomous scorpion with a lethal dose of around a third of a milligram of venom per kilo of bodyweight. A cocktail of toxins causes heart failure and pulmonary oedema (fluid in the lungs). The deathstalker's normal prey is locusts and crickets but it is a twitchy and aggressive creature that will sting anything that comes too close. Only its small size reduces the danger to humans; a typical sting only delivers 0.225 milligrams of venom and deaths are rare, except in small children and cases of allergic reaction. Nevertheless, antivenom is not as effective as it is for snakebites and a sting from a deathstalker is regarded as a medical emergency, even with prompt hospitalisation.



Stinger
The penultimate segment is darker due to the venom glands.

© Yair Goldstof

© Estel Inbar

DEADLY FACTOR

Deathstalker scorpion

AGGRESSION: High. A twitchy, trigger-happy stinger that attacks anything nearby.

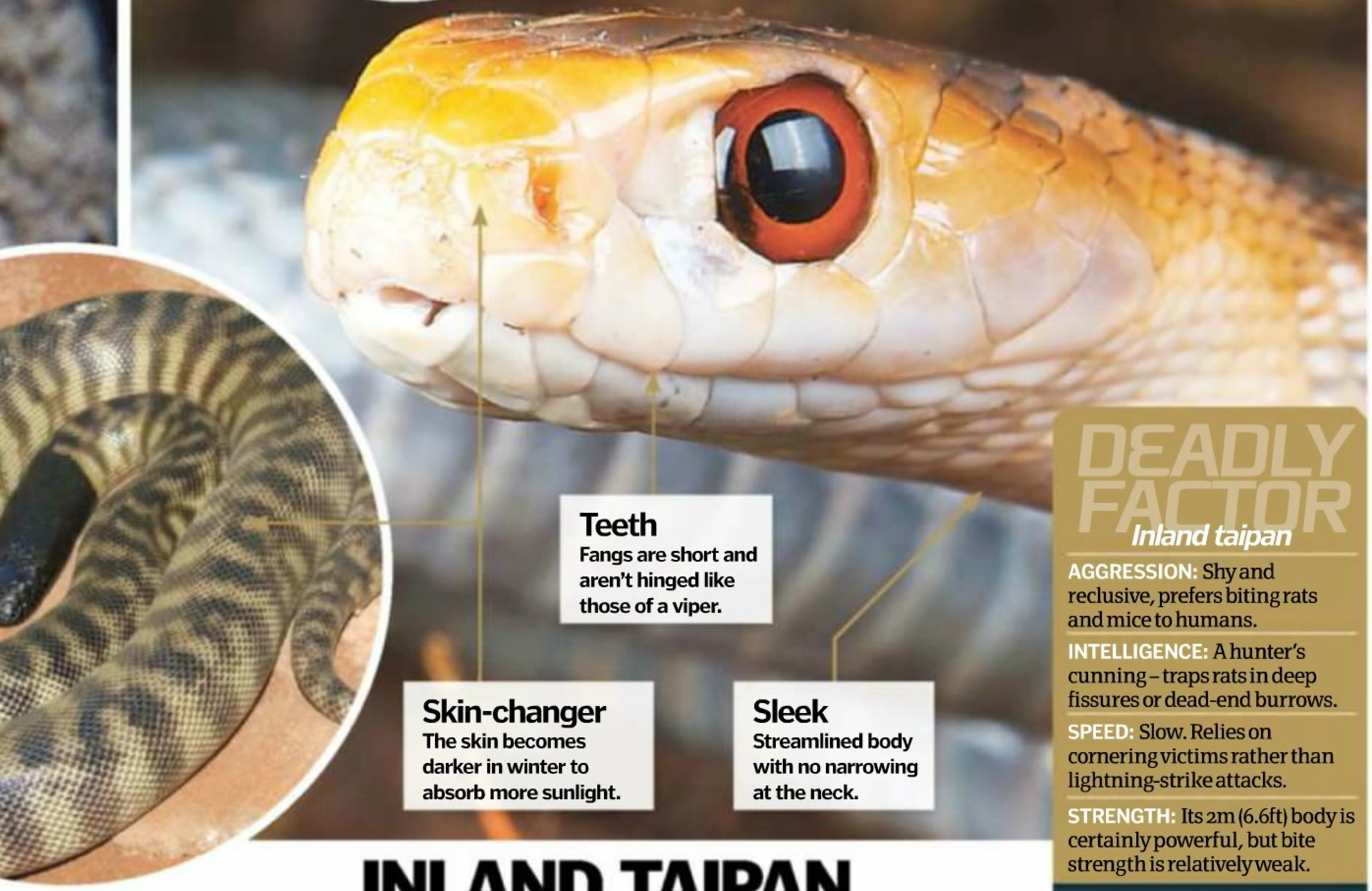
INTELLIGENCE: Low. Simple arachnid cunning designed to hunt down insects.

SPEED: High. The strike from the tail is impossible to dodge.

STRENGTH: Low. The pincers are there to grip small prey only.

DEADLY RATING: ☠☠☠☠

> "The lethal dose for a typical adult human is calculated to be around two milligrams"



Teeth
Fangs are short and aren't hinged like those of a viper.

Skin-changer
The skin becomes darker in winter to absorb more sunlight.

Sleek
Streamlined body with no narrowing at the neck.

INLAND TAIPAN

The inland taipan has the deadliest venom of any land animal; in fact, it is one of the most deadly substances of any kind. At least 40 times more powerful than the venom of a cobra, the lethal dose for a typical adult human is calculated to be around two milligrams; that's about as much as the blood you lose from a mosquito bite. A typical bite injects enough venom to kill 25 humans, or a quarter of a million mice! Fortunately, the inland taipan lives in extremely remote parts of central Australia where it very rarely comes into contact with people. For such a deadly creature, it is also very shy and, despite its other name – the fierce snake – it never attacks unprovoked.

DEADLY FACTOR

Inland taipan

AGGRESSION: Shy and reclusive, prefers biting rats and mice to humans.

INTELLIGENCE: A hunter's cunning – traps rats in deep fissures or dead-end burrows.

SPEED: Slow. Relies on cornering victims rather than lightning-strike attacks.

STRENGTH: Its 2m (6.6ft) body is certainly powerful, but bite strength is relatively weak.

DEADLY RATING: ☠☠☠

The statistics…

Inland taipan

Genus: Oxyuranus
Length: 1.8-2.5m (5.9-8.2ft)
Weight: 6kg (13.2lb)
Life span: 10-15 years

Blue-ringed octopus

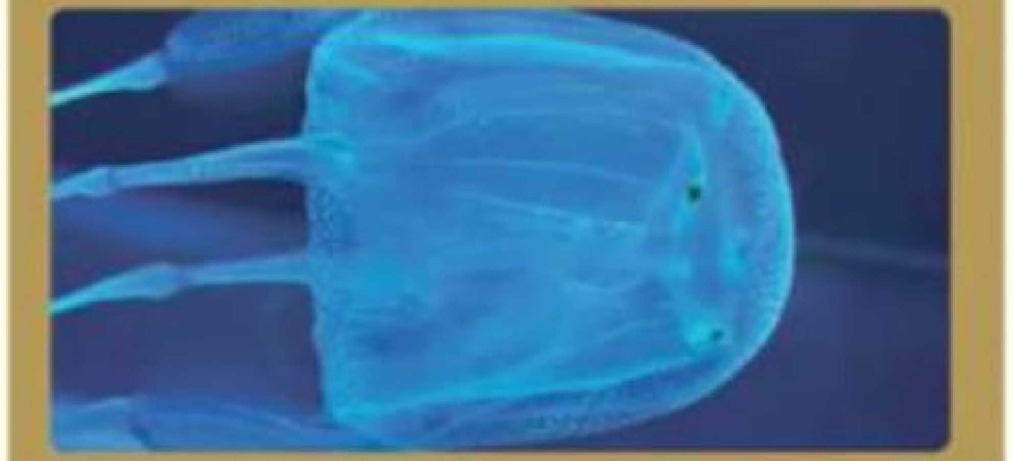
Continents: Oceania/Asia
Countries: Japan, Australia, Indonesia
Notable region: Southern New South Wales

Geography cone snail

Continent: Oceania
Countries: Australia
Notable region: Northern coast of Australia

BEST OF THE REST…

Nature has plenty more toxic creatures – here are just a few…



BOX JELLYFISH

Found in the waters of northern Australia, the box jellyfish has one of the most deadly venoms in the world. It attacks both the heart and nervous systems.

MOST PAINFUL VENOM

BLACK MAMBA

A native of eastern Africa, this long, highly venomous snake (actually brown in colour) can inject a whole bunch of nasty neurotoxins and cardiotoxins.

AFRICA'S MOST VENOMOUS SNAKE

STONEFISH

Not to be mistaken for a lump of coral, the stonefish delivers powerful neurotoxins from its dorsal spines; in fact, some think it's the most venomous fish in the world.

MOST VENOMOUS FISH

FUNNEL-WEB SPIDER

Unlike most other venomous spiders, the venom of the male funnel-web is more deadly than that of the female. These arachnids have super-powerful fangs.

AUSTRALIA'S MOST FEARED

Animal camouflage

The sneaky secrets of the most amazing animals you've never seen

Almost every animal has a good reason to hide. Going undetected makes it easier to catch food – and easier to avoid becoming someone else's. In any species, the individuals that stand out the most will be the first to be eaten and the last to catch their own dinner, and so natural selection picks the ones with the best camouflage.

There are several different kinds of camouflage. The most basic is to hide under a rock, or in sand or leaves. This is sometimes called 'crypsis', and some animals will incorporate bits of their environment on their bodies to improve the effect. Three-toed sloths have algae growing in their fur, which gives them a dark green hue that helps them hide among the trees. Coral crabs deliberately attach young polyps to their shells so they resemble part of the reef.

The next step is to change your own body colouration. Mammals have a colour pallet restricted to white, black, brown and yellow, but fish, amphibians, reptiles and birds can all produce a vivid array of greens and bright reds. Red might not seem like a great colour for camouflage, but lots of seaweed and corals are red, and in fact many sea creatures obtain the red pigment for their bodies by eating the corals and seaweed that they hide among.

Camouflage is a show, performed for a few specific observers. Most mammals see in black and white, or only two colours. Primates see three primary colours, while birds see four. Insects can see well into the ultraviolet part of the spectrum and many snakes can sense infrared. Choosing the right camouflage is about exploiting the weaknesses in your target's visual system. Even if your colour is a very close match to your surroundings, your outline can still give you away. One of the earliest parts of the brain to evolve was concerned with recognising the edges of things, and most animals still have a dedicated outline recognition brain region. Good camouflage uses contrasting patterns of light and dark, or different colours. These trick the outline recognition system so that it mentally carves up your shape into smaller, irregular blocks. In some environments, there is so little to hide behind that this

5 TOP FACTS MASTERS OF DISGUISE

Pink soft coral crab
1 This crab attaches coral polyps to its own shell as a sort of marine ghillie suit. With matching shell colouration from eating coral, it becomes a walking coral reef.

Sea dragon
2 The leaf-like protrusions on this relative of the seahorse make fast swimming impossible, but they do provide excellent camouflage.

Ghanaian praying mantis
3 Normally green, the Ghanaian praying mantis will moult its skin and change to a black colour after a forest fire, in order to retain its camouflage.

Leaf insect
4 The wide flattened body of the leaf insect looks just like a leaf, and the legs are disguised either as smaller leaves or as bite marks from the main leaf depending on the species.

Gaboon viper
5 A 1.5m snake that's as thick as your arm sounds hard to miss, but the incredibly disruptive pattern perfectly matches the jumble of dried leaves on the African forest floor.

DID YOU KNOW? [illegible]

A broadclub cuttlefish

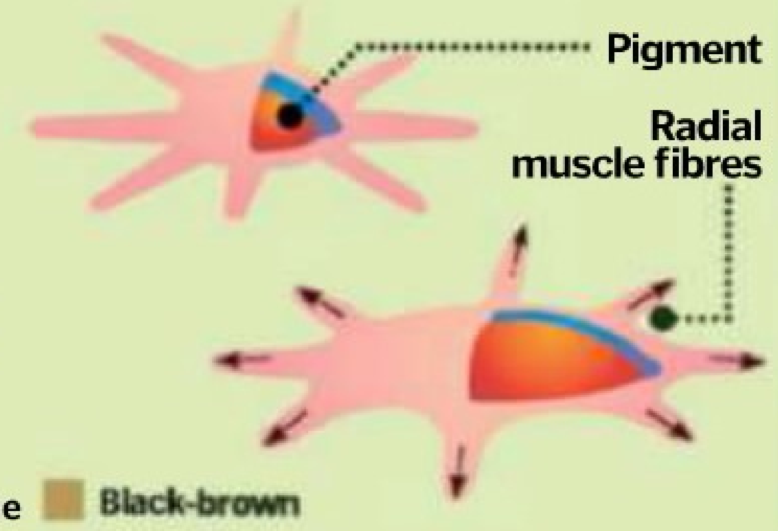
© Science Photo Library

How the cuttlefish gets its spots

Cephalopods – particularly the octopus and the cuttlefish – are the undisputed masters of the quick change. Their skin is packed with specialised cells called 'chromatophores' that change the colour or reflectivity of the skin. Each chromatophore has its own activating muscle and nerve fibre, and these are connected to a part of the brain dedicated to coordinating the complex patterns. Although the chromatophores only contain red, yellow and brown pigments, cuttlefish can create almost any colour by combining different layers of coloured and reflecting cells. Green, for example, is achieved by using an iridescent layer deep in the skin to scatter light back through yellow pigments, which act as a filter. All the layers are controlled independently and simultaneously, so a cuttlefish can change its entire skin colour in less than a second. Chameleons use a similar arrangement of skin cells but the chromatophores are controlled using hormones, rather than nerve impulses, so the change occurs more slowly.

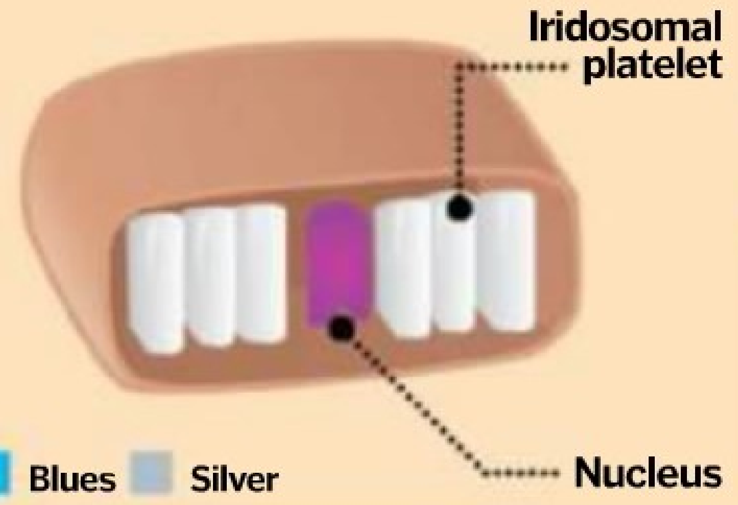
Under the skin

Chromatophore
When the cell is relaxed, the pigment forms an inconspicuous dot in the centre. By pulling the radial muscles, the chromatophore is stretched into a larger disc and the colour is visible.



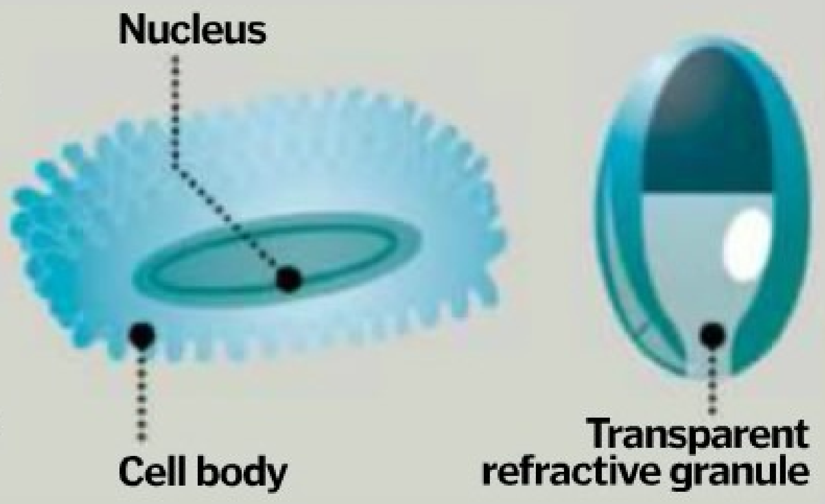
🟨 Orange-yellow 🟧 Red-orange 🟫 Black-brown

Iridophore
Iridophores generate iridescent colours using stacked crystals of translucent guanine proteins as tiny prisms. By altering the angle of the iridophore, the colour changes.



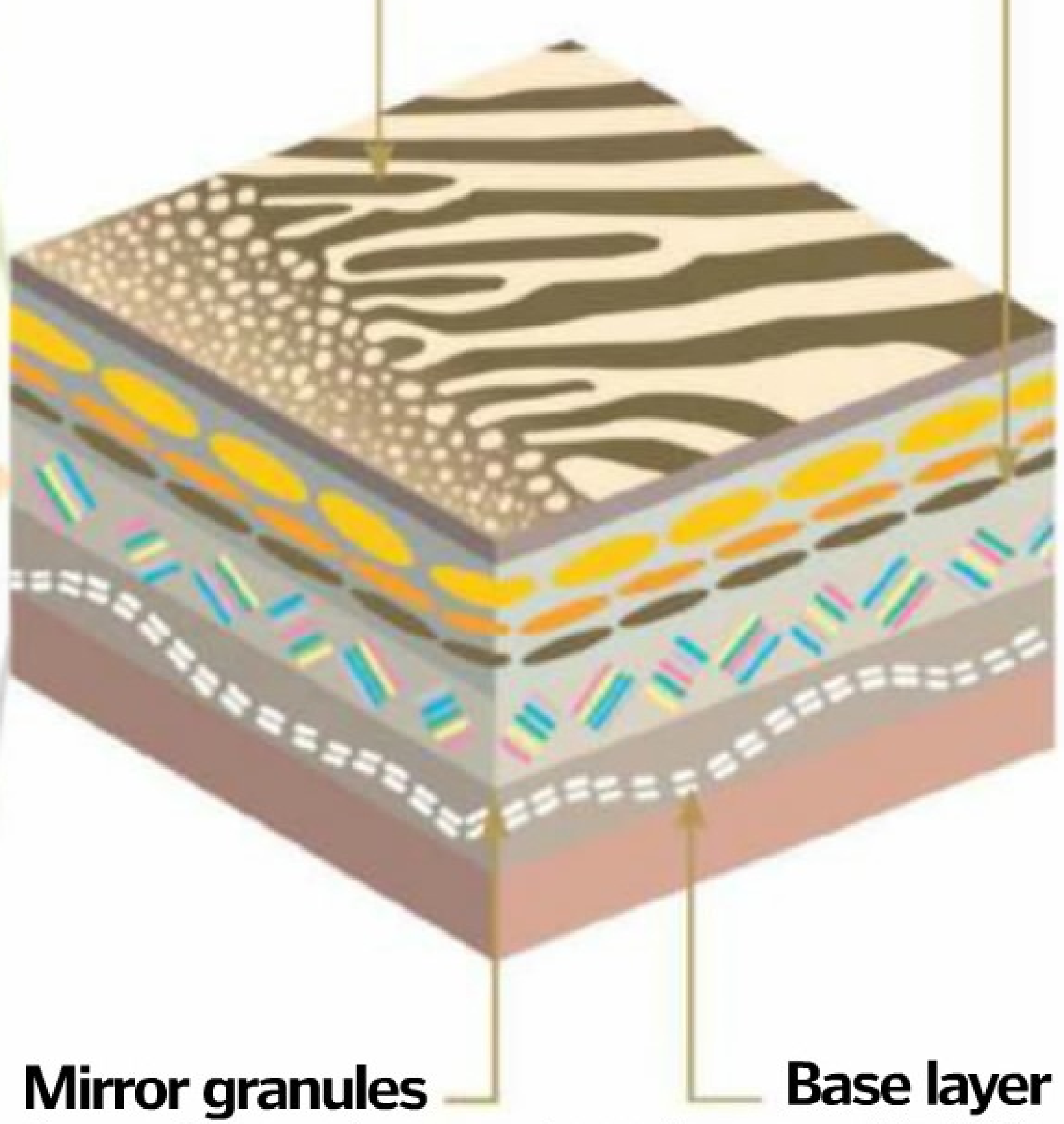
■ Pinks ■ Yellows ■ Greens ■ Blues ■ Silver

Leucophore
Leucophores use the same proteins as iridophores, but instead of stacking them in plates, the crystals are arranged on the surface of the cell. Squeezing or flattening the cell controls how much light is reflected.



Top layer
Stacked layers of chromatophores contain the three basic pigments. Reds, yellows, browns and black colours are all produced here.

Middle layer
The iridophores create interference patterns to generate shimmering, metallic patterns, and are also used to create blue and green colours.



Mirror granules
The guanine crystals are actually transparent, but by arranging them in tiny beads they act like crushed glass and form a white base.

Base layer
Leucophores are white. White is used as a danger signal by many octopuses, but this layer is also used as a 'base coat' to modify the colours of the chromatophores above.

'dazzle' camouflage is all you have. The Royal Navy used this technique in World War I, to make it hard to judge the speed and heading of battleships on the featureless ocean. But the orca, or killer whale, beat them to it by several million years. The bright patches of white on a black body disrupt its outline so that it is not immediately recognised as a threat. Zebras use the same technique, but this time the entire herd merges into one huge zebra that is much more intimidating and confusing to lions and cheetahs.

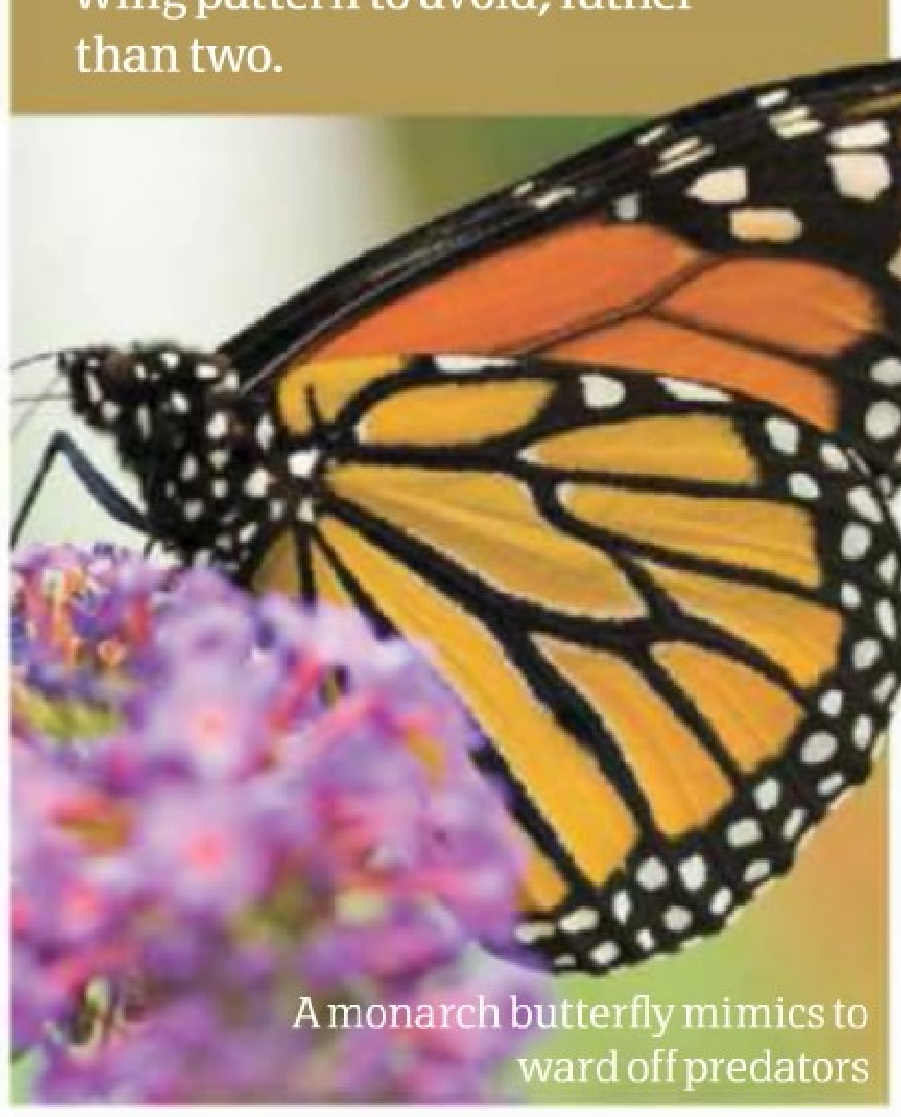
Sometimes, a purely visual camouflage isn't enough. Procrypsis is the technique of camouflaging your movement. Predators are acutely sensitive to movement, but a typical forest is a whirl of activity and they must quickly tune out the background motions of wind, water and all the non-food animals if they are not to be overwhelmed. Chameleons, leaf insects and preying mantises can exploit this by moving with a rocking motion that mimics the swaying of branches in the wind. Some Pacific octopuses will curl up like a rock, but still manage to move along the seabed by synchronising movement with the back-and-forth patterns of shadow cast by sunlight through the waves. ●

Harmless hoverflies can mimic wasps

© Entomart Dasysyrphus

What's brown and sticky? A stick!

Camouflage is usually about blending anonymously into the background, but there are times when it is better to disguise yourself as something specific. Mimics copy the shape, colouring, movement and sometimes even the smell of another species to fool prey or predators. This is an evolutionary arms race; as predators evolve more and more acute senses to see through the subterfuge, so the mimics must constantly refine their disguise. One of the most common forms of mimicry, known as 'Batesian mimicry', is where a harmless species pretends to be a dangerous one, such as the many species of hoverfly that mimic stinging wasps. But poisonous species can mimic each other, too. Monarch and viceroy butterflies show this kind of 'Müllerian mimicry' – both are toxic, but they have evolved to mimic each other so that bird predators only have to learn one wing pattern to avoid, rather than two.


A monarch butterfly mimics to ward off predators

Jungle illusionists

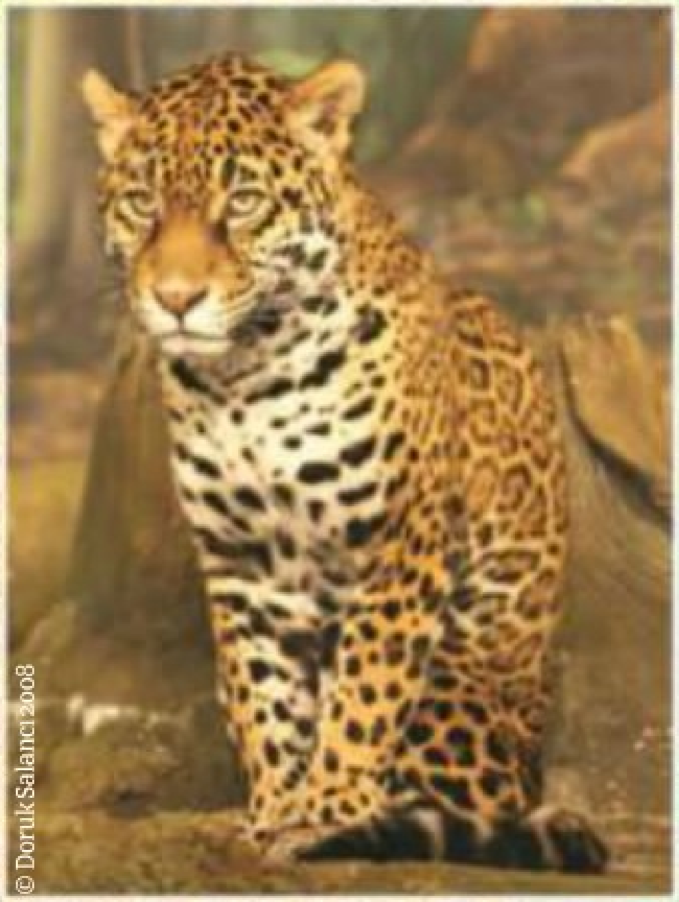
An impressive game of hide and seek takes place among the trees

Jackson's chameleon

Technique: Colour and movement
Reason: Hunting
In the lush, high-altitude forests of Kenya and Tanzania, the bright green skin of the Jackson's chameleon blends with the mosaic of thick waxy leaves. Their skin is mottled to break up the animal's outline and has very rough scales to create a thorny, irregular texture. When they perch, their long tail is coiled into a tight circle to help the chameleon look more like a leaf, and they move with a swaying motion to mimic the effect of the breeze through the branches.

Jaguar

Technique: Disruptive pattern
Reason: Hunting
Hiding 100kg of big cat in the dense forests of south America isn't easy, but if you are an ambush predator, it's vital that you succeed. Jaguars use a similar rosette pattern on their fur to the African leopard but the rosettes are larger, darker and have a small spot in the middle. The effect is similar to the dappled shade cast by the thick jungle foliage on the forest floor. This makes it very hard to trace the outline of the jaguar, until it moves. And by then, it's too late.



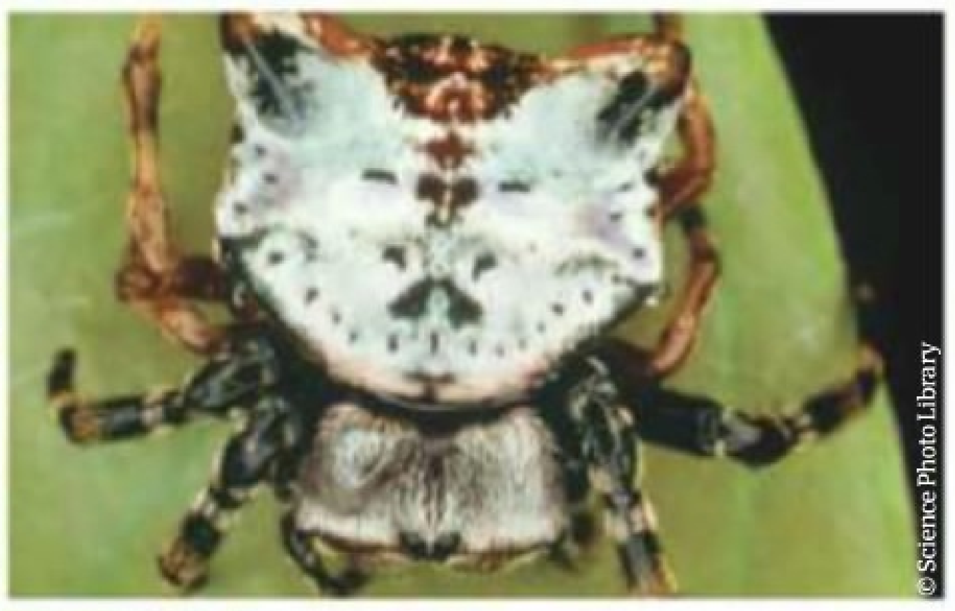
© Doruk Salanci 2008

© Fanny Schertzer

© Podargus strigoides Bonorong

Tawny frogmouth

Technique: Disruptive colour pattern
Reason: Defensive
This distant relative of the owl and cuckoo lives in Australia and New Guinea. It eats insects and small frogs by sitting still until food comes within range, and then pouncing. It feeds at night, so the camouflage is to protect it during the day. Perched motionless in the crook of a tree branch or on a dead log, the pattern of its feathers mimics the texture of tree bark.



© Science Photo Library

Bird dropping spider

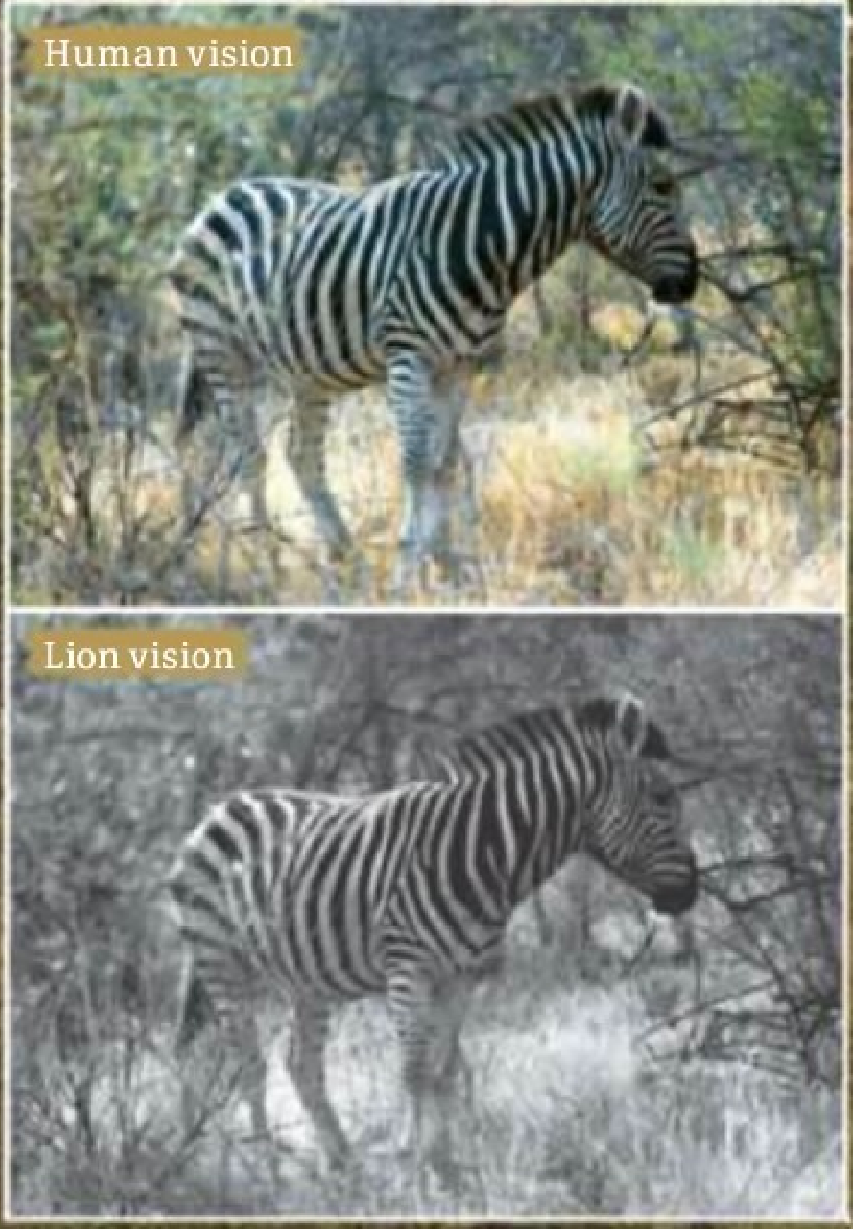
Technique: Mimicry
Reason: Defensive
This Australian spider catches moths at night by luring them with their own sex pheromones, but during the day it is vulnerable to being eaten by birds. So it disguises itself as the least appetising thing for a bird: their own droppings! The creamy-coloured abdomen with brown stippled patches closely resembles the guano of a bird that feeds on insects.

Israeli sand gecko

Technique: Colour and counter-shading
Reason: Protection and hunting
Sand geckos use the huge surface area on their finger pads to cling to the walls or roofs of rock crevices in the desert. The mottled sandy colour that covers all of their upper surface, including their eyelids, blends against the gritty sandstone rocks. When they are the right way up, hunting insects on the desert floor, their white belly appears to neutralise the shadow cast by their upper body.

Lying low on the land

The land is home to many sly creatures, so watch your step



A lone zebra is easier for lions and other predators to see, compared to when they're huddled together

© Ikiwaner

DID YOU KNOW?

© Richard

Chameleon changes

The word 'chameleon' is a by-word for invisibility and camouflage, but most chameleons don't change colour to match their surroundings. Their default colour is already an excellent camouflage and colour changes are used to signal their mood to other chameleons.

DID YOU KNOW? *The Indonesian mimic octopus is so good at hiding that it wasn't officially discovered until 1998*

Invisible mysteries of the deep

Below the surface of the water lurk a talented band of beasts

Zebra

Technique: Dazzle pattern
Reason: Confusing predators

The African savannah is a difficult place to hide, but the bright stripes of the zebra work in a different way. Instead of making the animal blend into its surroundings, they make it blend into the herd. When threatened, zebras huddle together and the stripes make it difficult to tell where one starts and another ends. Lions and other predators rely on splitting one target away from the herd. The visual clump created by the stripes confuses and acts as a survival technique for the zebra.

Mackerel

Technique: Stripes and counter-shading
Reason: Defensive

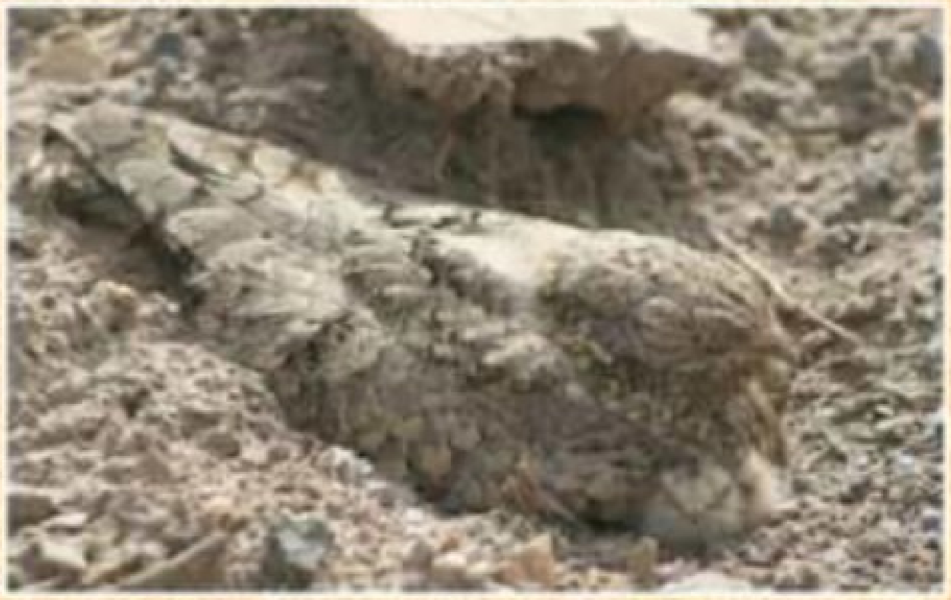
Mackerel swim in huge schools. Seen from above, the distinctive striped pattern resembles the rippling pattern of shadow seen in shallow seas. At close range the effect may be similar to the zebra's stripes and make it hard for predators to lock on to any single fish. The counter-shaded belly is common to most fish, making them harder to spot from below against the lighter surface.

© Science Photo Library

Snowshoe hare

Technique: Seasonal colour
Reason: Defensive

During the short Alaskan spring and summer, the snowshoe hare has fur that is standard 'rabbit brown' to blend against the leaves and heather. But this hare doesn't hibernate and a brown animal wouldn't last long on a carpet of snow, with lynx and great horned owls patrolling. So it moults to a winter coat, which is pure white except for a black tip on each ear.



Egyptian nightjar

Technique: Colour and pattern
Reason: Protecting its eggs

Birds normally defend themselves against predators by flying away, but the Egyptian nightjar lives in the desert, where there are no trees for roosting. It also eats moths, which means it is active by night. In the day it rests on the sandy ground, but its mottled brown, rather scruffy-looking plumage is almost impossible to spot. The nightjar just looks like a stone or a piece of dried wood. Egyptian nightjars don't even build nests, hiding their eggs beneath their own camouflage.

Stonefish

Technique: Colour and spines
Reason: Ambush

The stonefish catches small fish and shrimp by lying still on the seabed and resembling a stone. When food swims close, it pounces and then goes back to being a stone. To defend itself from its own predators, the stonefish has 13 poisonous spines. Whereas most poisonous animals are brightly coloured as a warning, the stonefish's camouflage means that it's often trodden on by accident, killing a human in two hours.

© Silke Baron

Cuttlefish

Technique: Colour changing
Reason: Signalling, hunting and protection

Cuttlefish have the most advanced colour changing system of any animal. Not only can they change their colour in less than a second, but they can also move from static camouflage patterns to rapidly pulsing displays to hypnotise prey or communicate with other cuttlefish. Their skin can also change the polarisation of the light reflecting off it, important because many marine animals are sensitive to the polarisation angle of light.

Indonesian mimic octopus

Technique: Colour changing and behavioural mimicry
Reason: Protection and hunting

The mimic octopus is an active predator and can't afford to spend long periods sitting on the seabed pretending to be a rock. But it does have lots of predators of its own, so uses its camouflage abilities to imitate more than 15 other animal species. As well as changing the colour and patterning of its skin, it can also radically alter its texture from smooth to spiny and contort its arms and body to change shape.

© Science Photo Library

THE PLANET'S WEIRDEST ANIMALS

Meet ten of the world's strangest creatures and find out why they have evolved to be so odd

You probably think you've seen everything the animal kingdom has to offer. There are a million species of beetle, but they all basically look like beetles, after all. A little bigger here, a different colour there, perhaps some horns. But all quite recognisable. The animals that are most common in the world are those that exploit a wide ecological niche. They are familiar because they are successful, and because their evolution has supplied lots of very minor variations on those themes. But there are other animals that have evolved to exploit very specific niches; specialists that live in some of the remotest, strangest and harshest environments on Earth. For these animals, the standard body shape and the normal lifestyle strategy just isn't enough. They exist at the extreme edge of the natural selection envelope. Their bodies have distorted to such an extent that their common name often mistakes them for something else entirely: the toad that is really a lizard; the butterfly that's a snail; the mole rat that's neither a mole nor a rat. To us, they are weird. But if you lived where they do, you'd quickly realise there is simply no other way to survive.

5 TOP FACTS
PREHISTORIC WEIRDOS

Therizinosaurus

1 Although it is thought to have been herbivorous, this five-ton dinosaur had the largest claws ever – three on each hand, each reaching up to a metre (3.2 feet) in length!

Sharovipteryx

2 Unlike pterodactyls, this gliding reptile had its main wing membranes stretched between its hind legs, with a second, smaller pair on the front – possibly for steering.

Opabinia

3 Five eyes and a backwards-pointing mouth that was fed from a single clawed tentacle are the features that qualify the opabinia for a place in this roundup. Was it a crustacean? A sort of worm? No one is really sure.

Argentavis

4 A feathered bird, from around 6 million years ago. It was as tall as a man and had a seven-metre (23-foot) wing span. It's believed to have grabbed prey without landing and swallowed it whole.

Hallucigenia

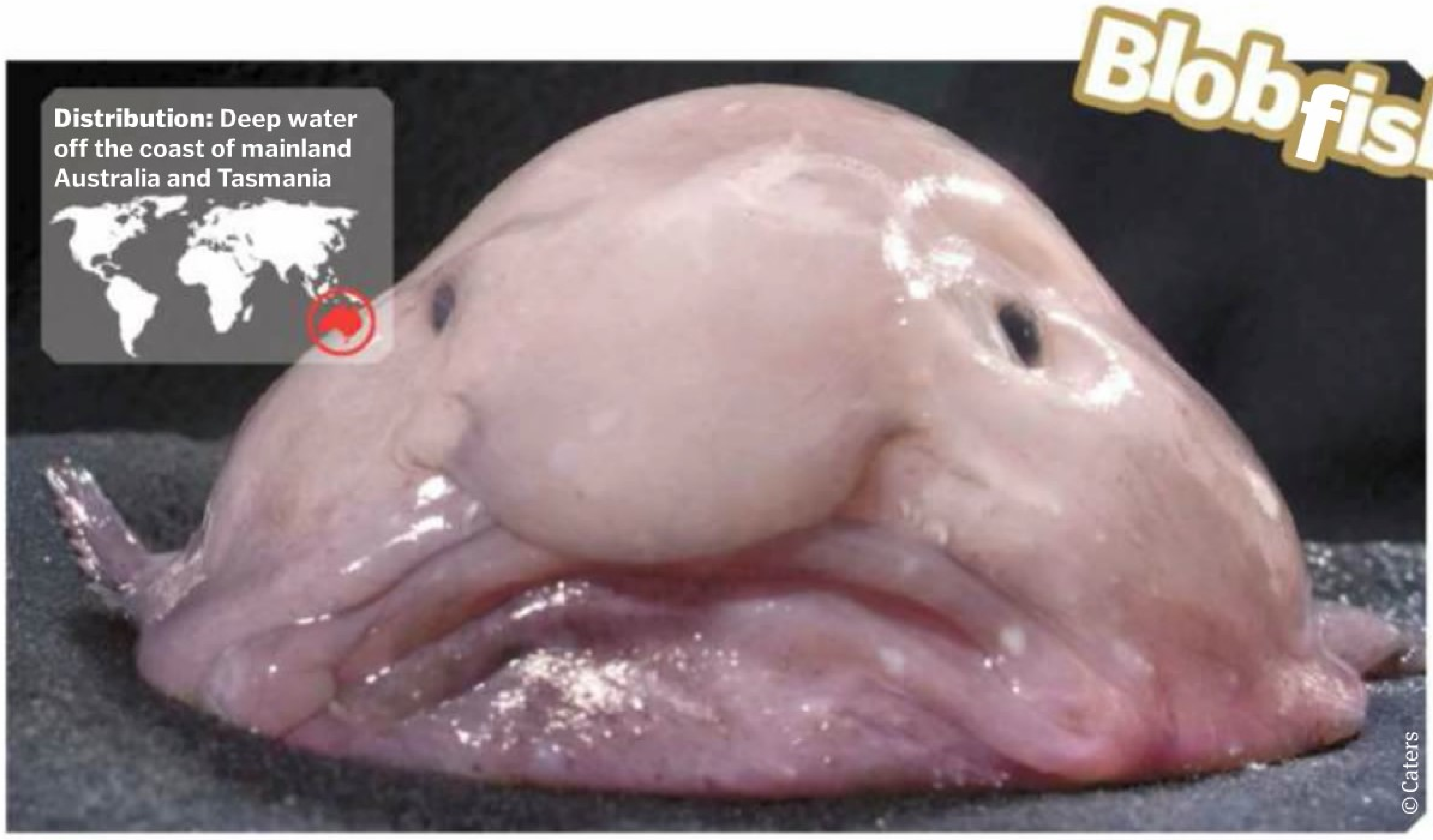
5 This strange worm from 500 million years ago had spines and tentacles that ended in pincers. Scientists still aren't sure how it fed or even which way up it went!

DID YOU KNOW? Star-nosed moles can smell underwater by blowing out a stream of bubbles and then breathing them back in

Blobfish

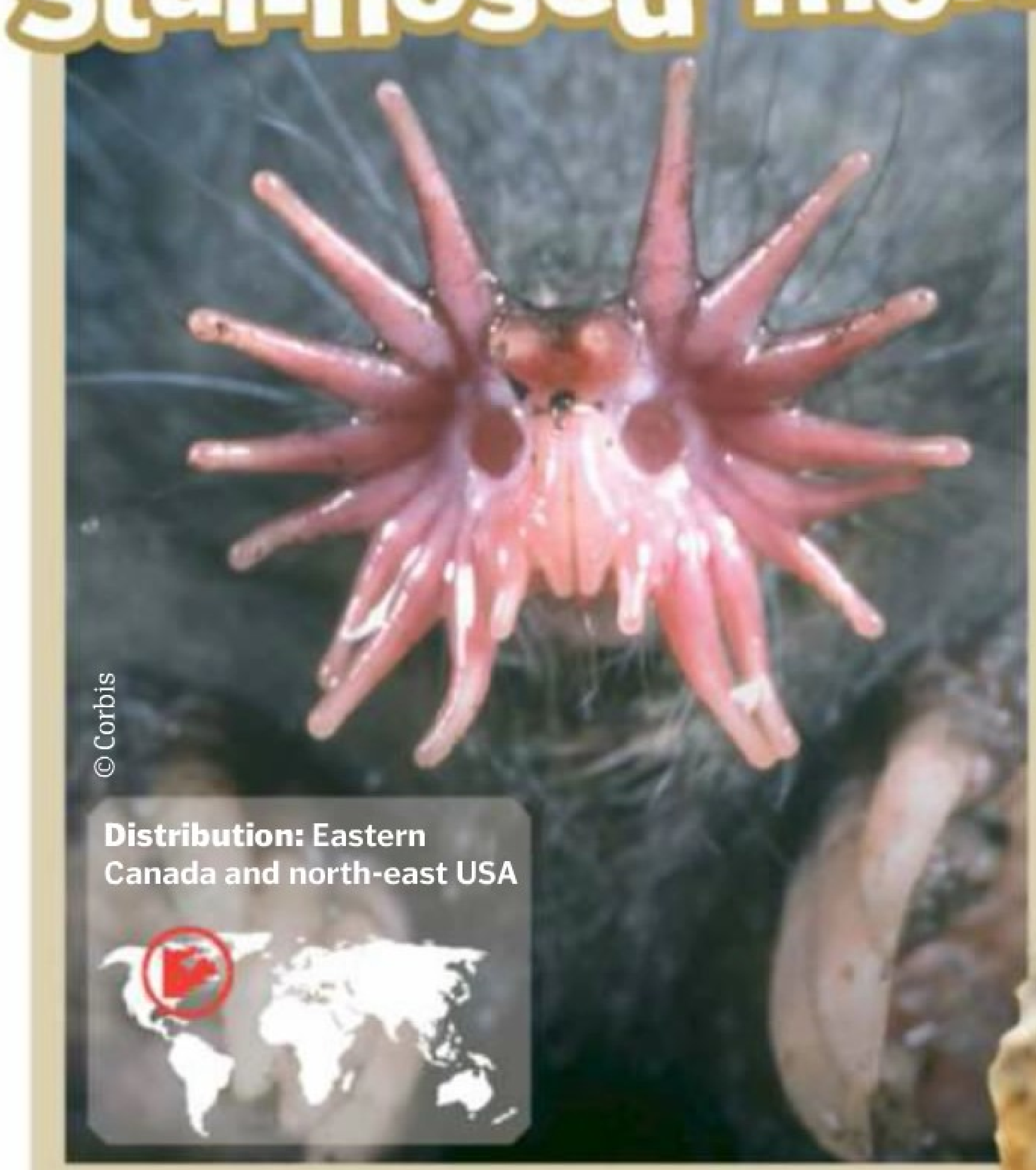
Deep-sea gelatinous mass

The blobfish is adapted to live in water 0.8 kilometres (half a mile) deep. At this depth the pressure is 80 times higher than at sea level and a normal gas-filled swim bladder is almost useless. Most creatures at these depths give up trying to swim entirely and simply walk or flop along the seabed. But flopping requires more energy and the blobfish is much too lazy for that. It has traded almost all its muscle mass for a jelly that is just slightly less dense than water. This allows it to coast just above the ocean floor. It doesn't chase its prey, but simply swallows anything that's slow or careless enough to get in the way of its mouth. Unusually for a fish, the female 'sits' on her eggs, instead of just abandoning them after laying. This is probably to protect them from being eaten by other blobfish in the vicinity.


Distribution: Deep water off the coast of mainland Australia and Tasmania

© Caters

Star-nosed mole

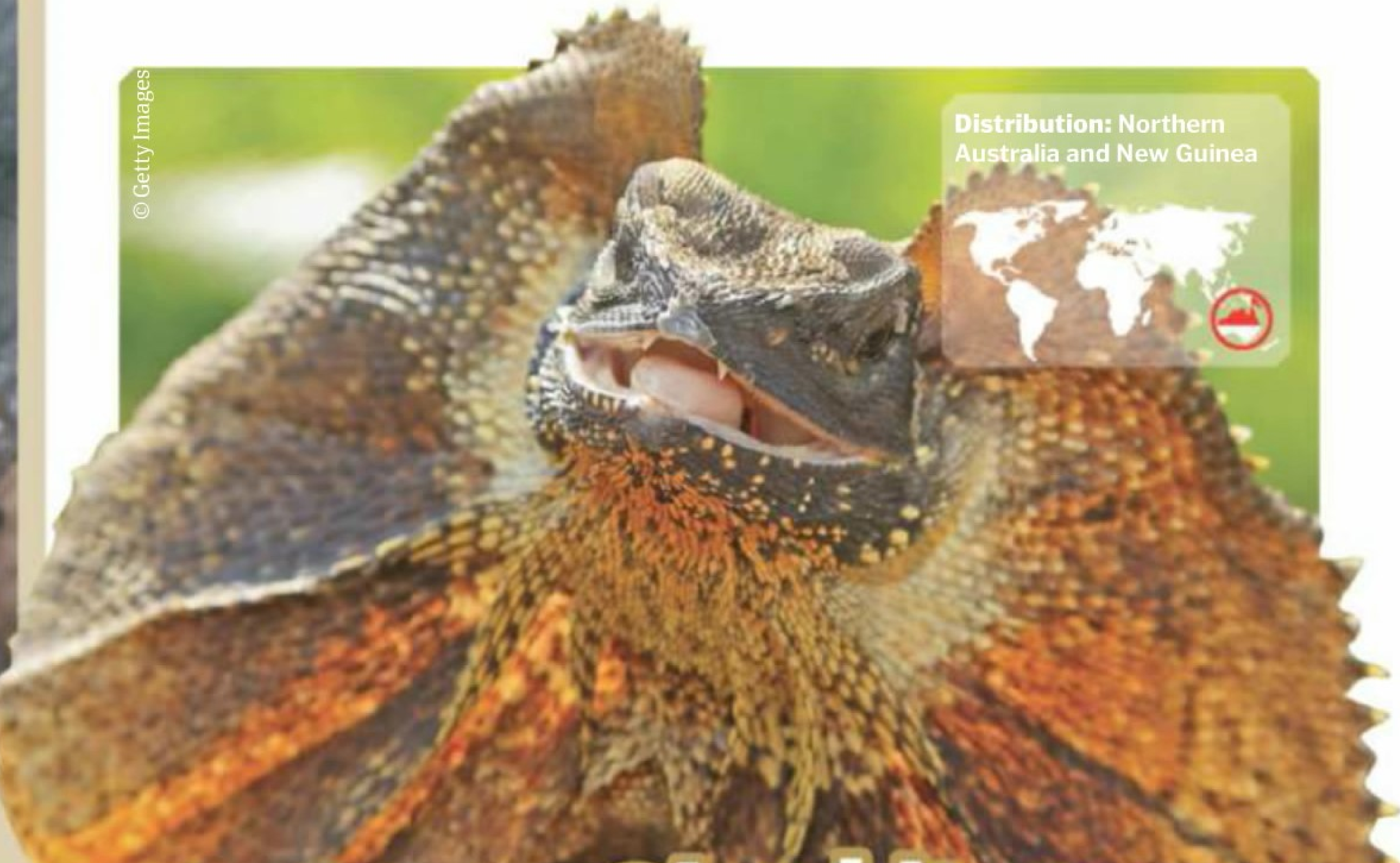

Distribution: Eastern Canada and north-east USA

© Corbis

"Working in total darkness, the mole can discriminate between an edible larva and a stone or empty shell in 17 milliseconds"

22 fingers attached to its nose

The star-nosed mole is the world's fastest-eating mammal. It takes less than a fifth of a second for it to identify if an object is edible and gobble it up. The secret is the ring of 22 tentacles around its nose. These are covered with 25,000 super-sensitive touch receptors, called Eimer's organs. Working in total darkness in a tunnel, or underwater, the mole can discriminate between an edible larva and a stone or empty shell in 17 milliseconds. This is so fast that its brain is working almost at the physical limit of the nerve fibres. Star-nosed moles use this ability to eat very small insects and crustaceans that wouldn't be worth the effort for a slower diner. They are also excellent swimmers and maintain a network of riverbank tunnels up to 270 metres (886 feet) long.


Distribution: Northern Australia and New Guinea

© Getty Images

Frill-necked lizard

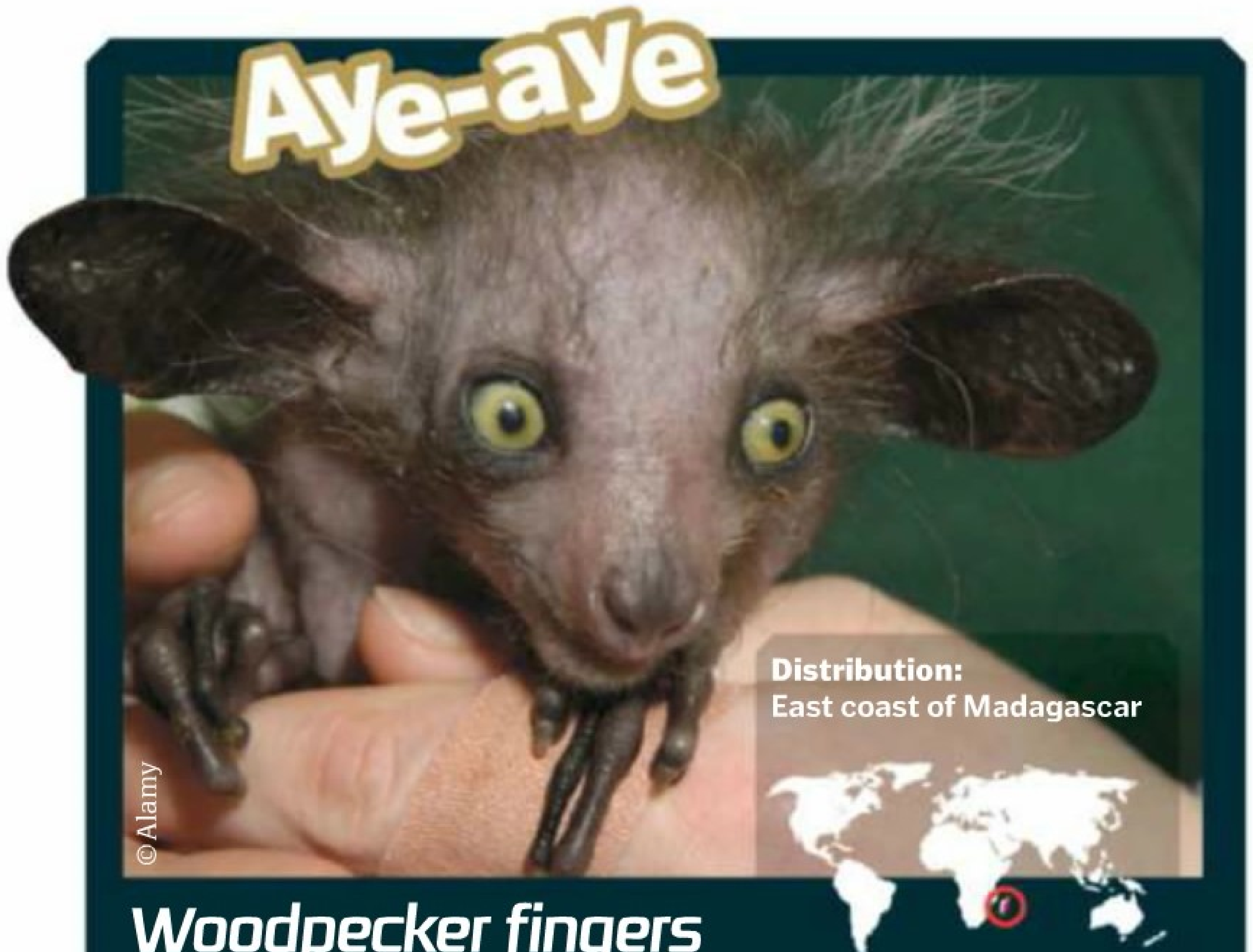
Wears an Elizabethan collar

Frill-necked lizards are almost a metre (3.3 feet) long with colours ranging from green to dark orange. They are all the same species though; the colour varies to match the local vegetation. Frill-necked lizards have a fan of cartilage spines around their head, supporting a wide flap of skin. The spines are connected to the base of the tongue so, when the lizard gapes its mouth, the frill spreads wide. This is used to scare away predators and also for courtship signalling.

They are also the only lizards that can balance properly on two legs; other lizards can run on their hind legs but they fall forward as soon as they slow down.

Wonders of evolution

Aye-aye

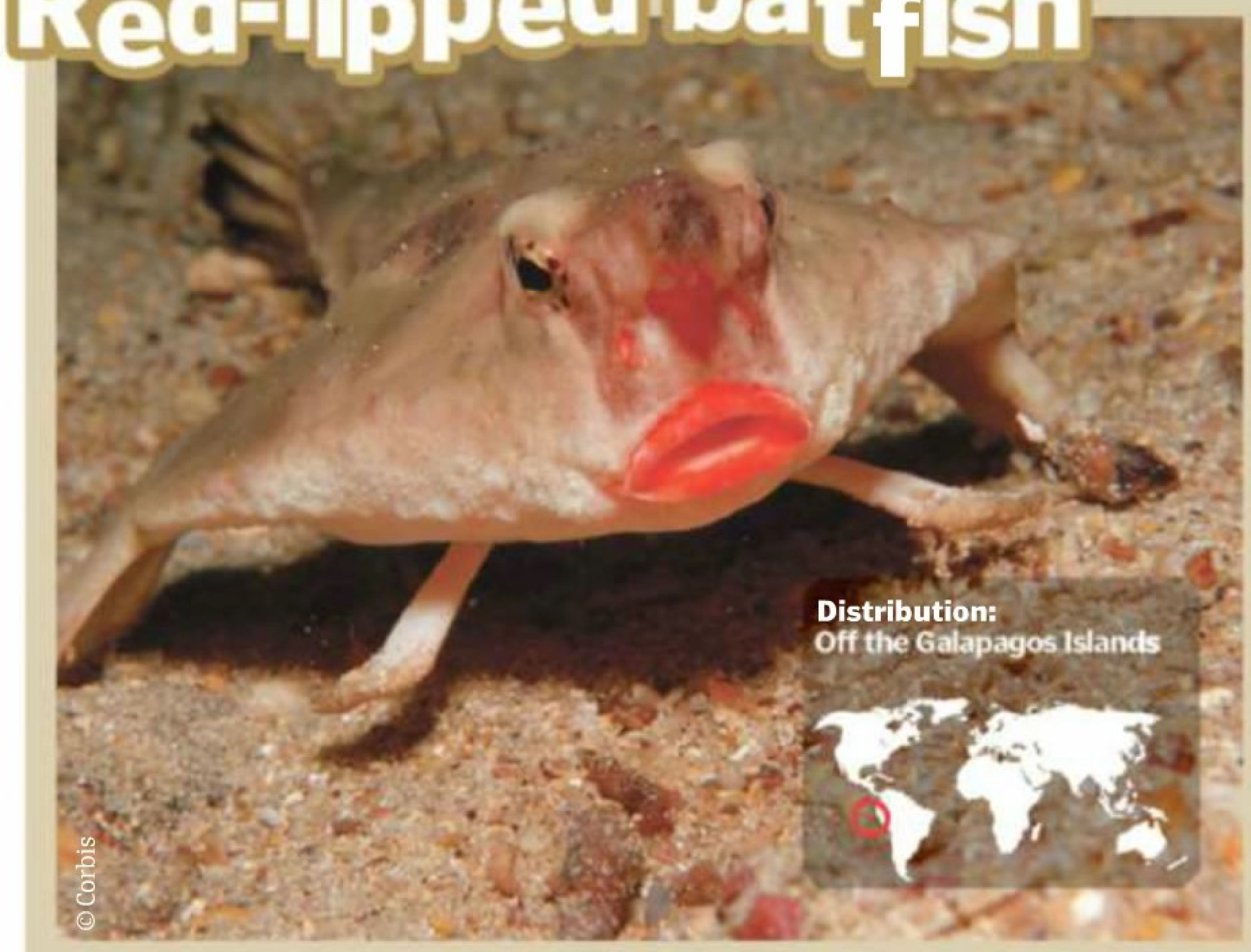

© Alamy

Distribution:
East coast of Madagascar

Woodpecker fingers

The aye-aye is the largest nocturnal primate. When leaping from tree to tree, it uses its excellent night vision, but when hunting for food it switches to a form of echolocation. Aye-ayes eat insect larvae that burrow in tree trunks. To find them they use their middle finger, which is especially long, as well as thin and bony. By rapidly tapping on the trunk they send vibrations through the wood. After each tap, the fingernail drags lightly along the bark to sense the return echoes and the aye-aye's huge ears enfold the target area to listen for changes in the pitch of the drumming sound. When it finds a hollow channel, the aye-aye uses its forward-slanting teeth to gnaw a hole in the bark and its long finger then does double duty as a specialised winkling tool to extract the juicy grub inside.

Red-lipped batfish

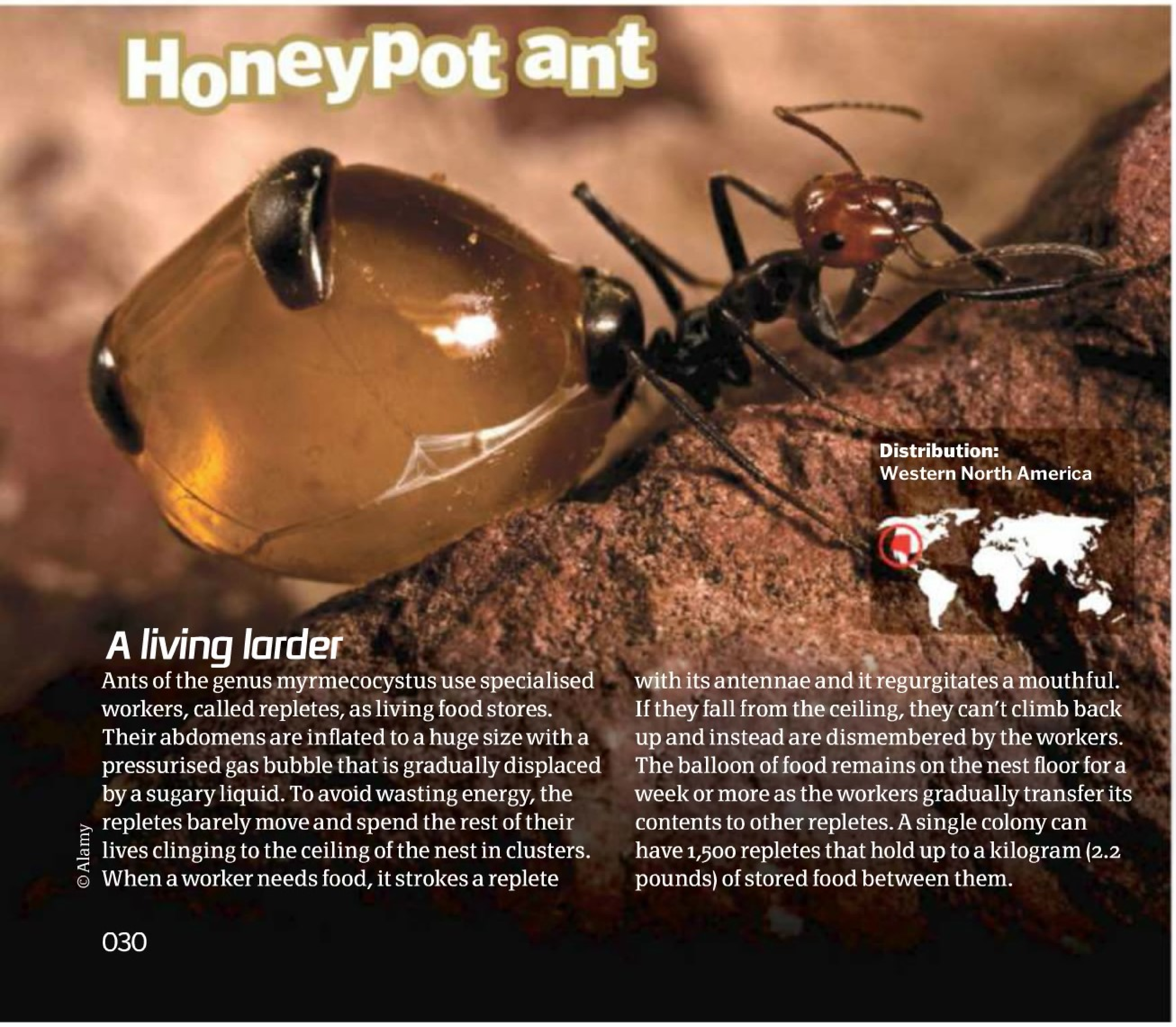

© Corbis

Distribution:
Off the Galapagos Islands

A walking fish with lipstick

This fish lives on the rocky seabed of the Pacific. Because the floor is rough and spiky, it prefers not to swim along the bottom like a flounder – instead it has evolved pectoral fins that work like legs to 'walk' along the seabed. It doesn't use its dorsal fin for swimming either; this has evolved into a spiny projection with a retractable 'fishing rod', which it uses to lure in small fish and shrimp. And the bright red lips? It turns out they really do perform a similar function to lipstick. The batfish uses them to help improve species recognition when searching for a mate.

HoneyPot ant


© Alamy

Distribution:
Western North America

A living larder

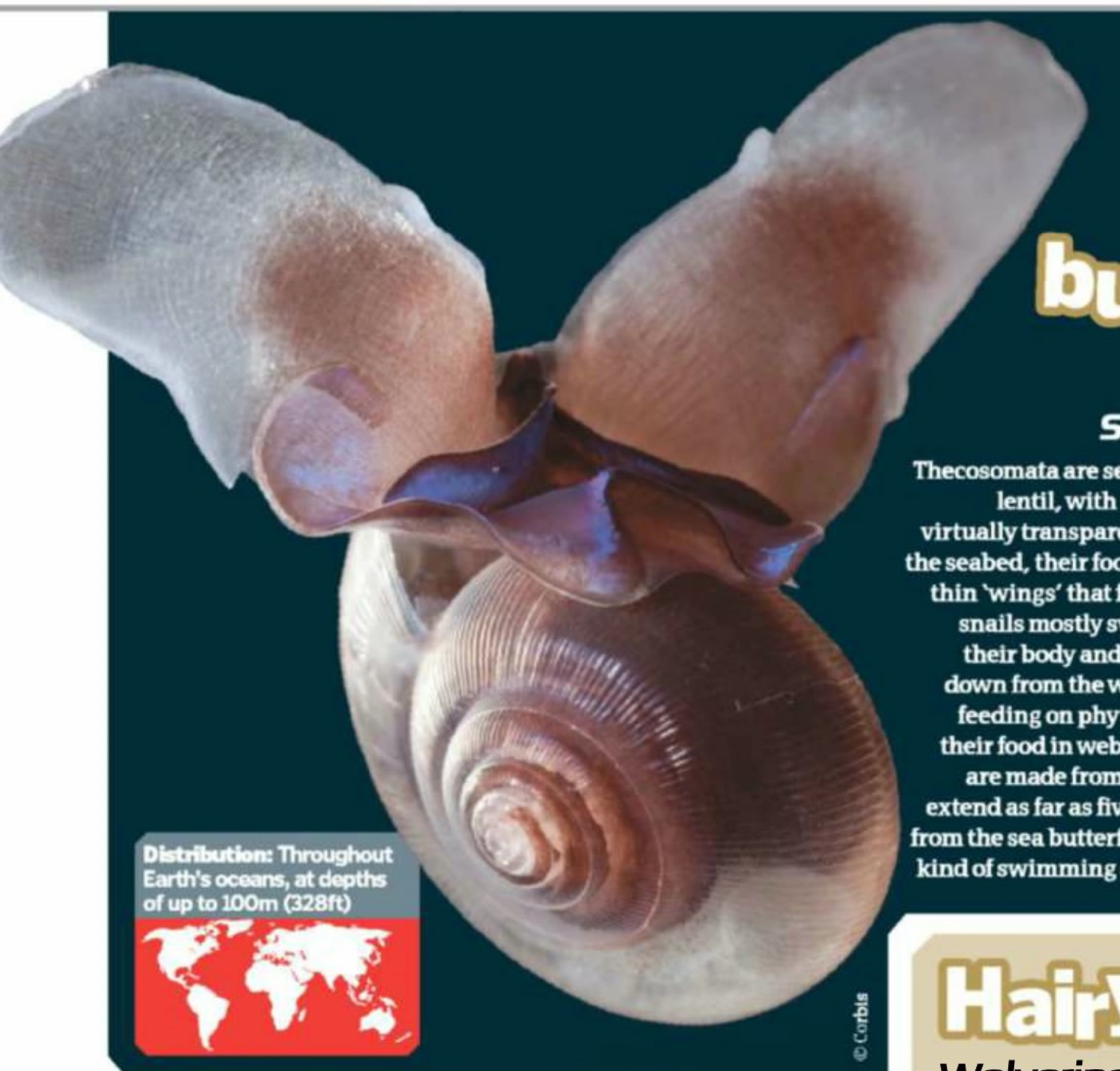
Ants of the genus myrmecocystus use specialised workers, called repletes, as living food stores. Their abdomens are inflated to a huge size with a pressurised gas bubble that is gradually displaced by a sugary liquid. To avoid wasting energy, the repletes barely move and spend the rest of their lives clinging to the ceiling of the nest in clusters. When a worker needs food, it strokes a replete with its antennae and it regurgitates a mouthful. If they fall from the ceiling, they can't climb back up and instead are dismembered by the workers. The balloon of food remains on the nest floor for a week or more as the workers gradually transfer its contents to other repletes. A single colony can have 1,500 repletes that hold up to a kilogram (2.2 pounds) of stored food between them.

Distribution:
Southern USA and Mexico

Rodents that live like bees

The nest of a naked mole rat is really not a comfortable place. The network of tunnels under the East African grassland is baking hot by day, freezing at night and almost airless. Life is so harsh that the naked mole rat lives as a hive organism with sterile workers and a single breeding queen. Naked mole rats can run backwards just as fast as forwards and have no sense of pain in their skin. Their metabolism is 30 per cent slower than other mammals of their size. Surprisingly, they have the longest rodent life span (28 years) and never get cancer.

DID YOU KNOW? *The lips of the naked mole rat are sealed behind its incisors, so it doesn't swallow dirt when digging*


Distribution: Throughout Earth's oceans, at depths of up to 100m (328ft)

© Corbis

Sea butterfly

Upside-down swimming snail

Thecosomata are sea snails about the size of a lentil, with shells so thin that they are virtually transparent. Rather than sliding on the seabed, their foot has evolved into a pair of thin 'wings' that flap through the water. Sea snails mostly swim upside down because their body and shell is heavier and hangs down from the wings. They are herbivores, feeding on phytoplankton, but they catch their food in webs, like spiders. These webs are made from strands of mucus that can extend as far as five centimetres (two inches) from the sea butterfly. They are preyed on by a kind of swimming sea slug called a sea angel.

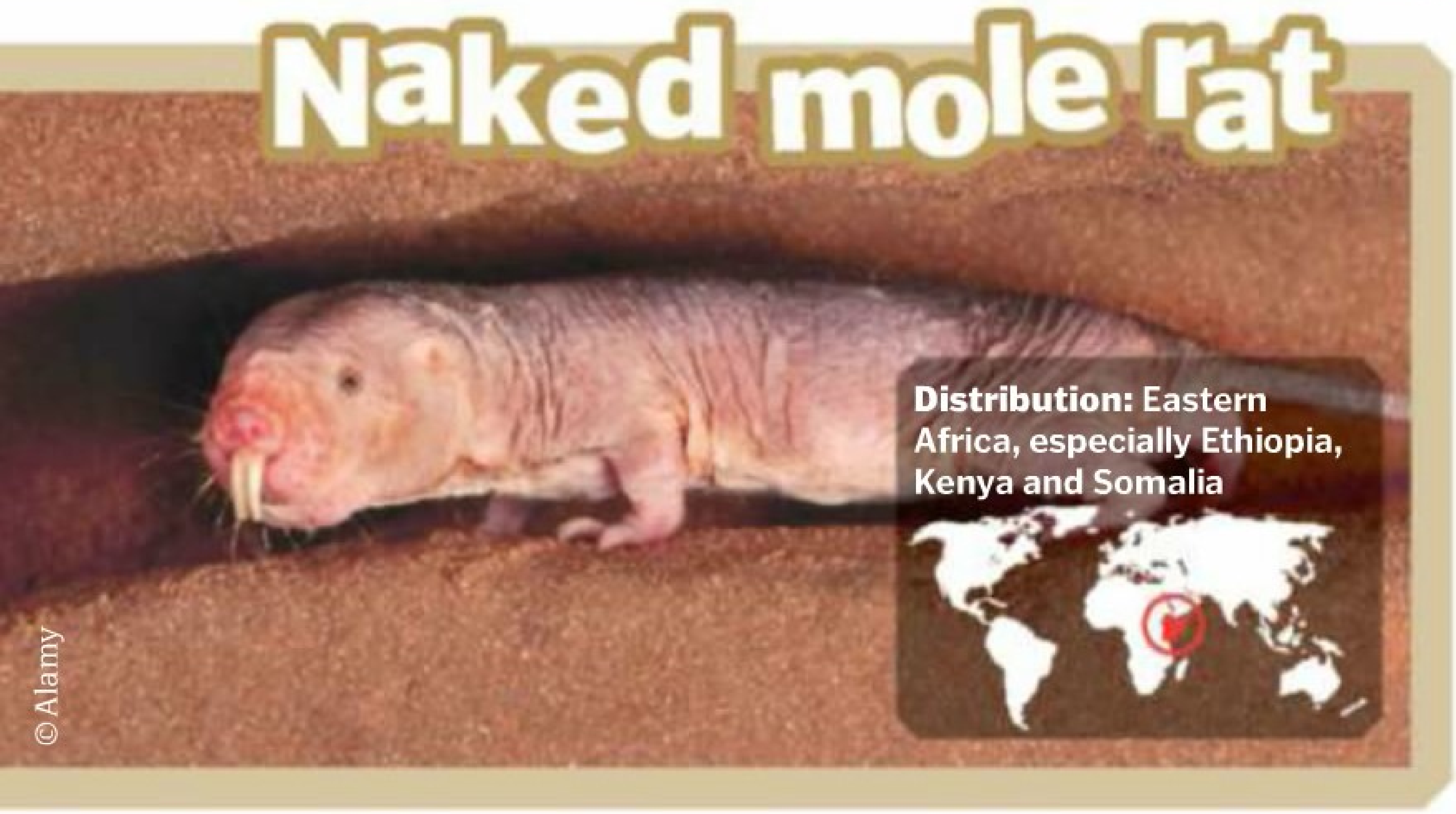
© Alamy

Texas horned lizard

The ultimate blood-shot eyes

The horned lizard is camouflaged, spiky and can inflate itself like a pufferfish. But just in case that isn't enough to deter predators, it has one last defence to deploy. By closing off certain blood vessels, the horned lizard abruptly increases the blood pressure in its head. This ruptures capillaries near the corners of its eyes and a jet of blood squirts from each, as far as 1.5 metres (five feet). In a single squirt, the lizard can lose a third of its total blood. Texas horned lizards eat Maricopa harvester ants, which have the most toxic venom of any insect. But far from poisoning the horned lizard, these toxins are stored and injected by special glands into the liquid projectile to cause a nasty burn.

Naked mole rat

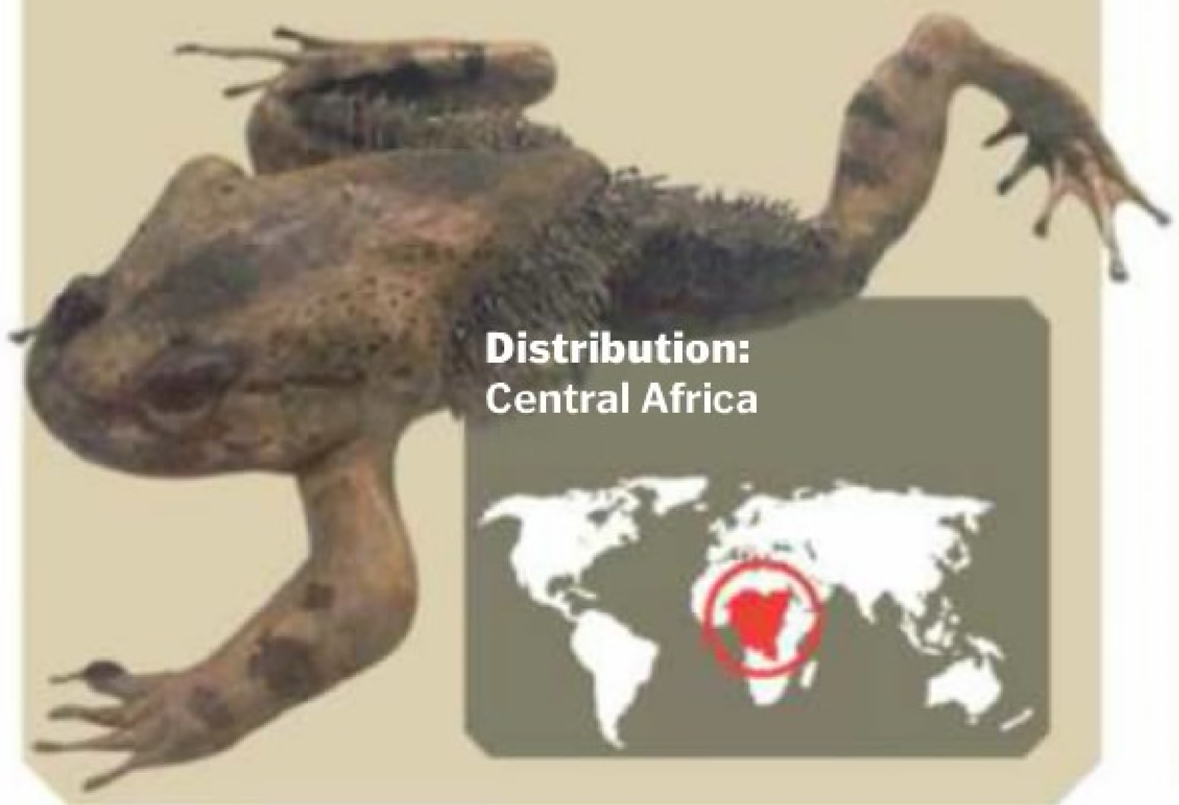

Distribution: Eastern Africa, especially Ethiopia, Kenya and Somalia

© Alamy

Hairy frog

Wolverine of the amphibian world

This 11-centimetre (4.3-inch) frog appears to have tufts of hair on its sides and thighs, but they are actually dermal papillae – fleshy outgrowths that contain arteries. They act to massively increase the skin surface area, which allows the hairy frog to absorb more oxygen when sitting underwater. But it's not just its 'sideburns' that make the hairy frog resemble X-Men's Wolverine. It can also extrude sharp claws by intentionally forcing them through its skin. The spines are normally held in place with a ligament but, when threatened, the frog clenches its fist so forcefully that the ligaments snap and pierce its skin. Unlike Wolverine, the spines can't be actively retracted; they just ease back over time and the skin regrows over them.


Distribution: Central Africa

Honourable mentions

Nature's capacity for weirdness is unlimited. Here are some more that didn't make the top ten

© Alamy

Axolotl
A kind of salamander that's able to regenerate severed limbs.

Butterfly lizard
Endemic to Vietnam, this reptile can clone itself asexually.

Dumbo octopus
This cute sea-critter gets about by flapping its ear-like fins.

Glass frog
A frog so transparent that you can see all its internal organs.

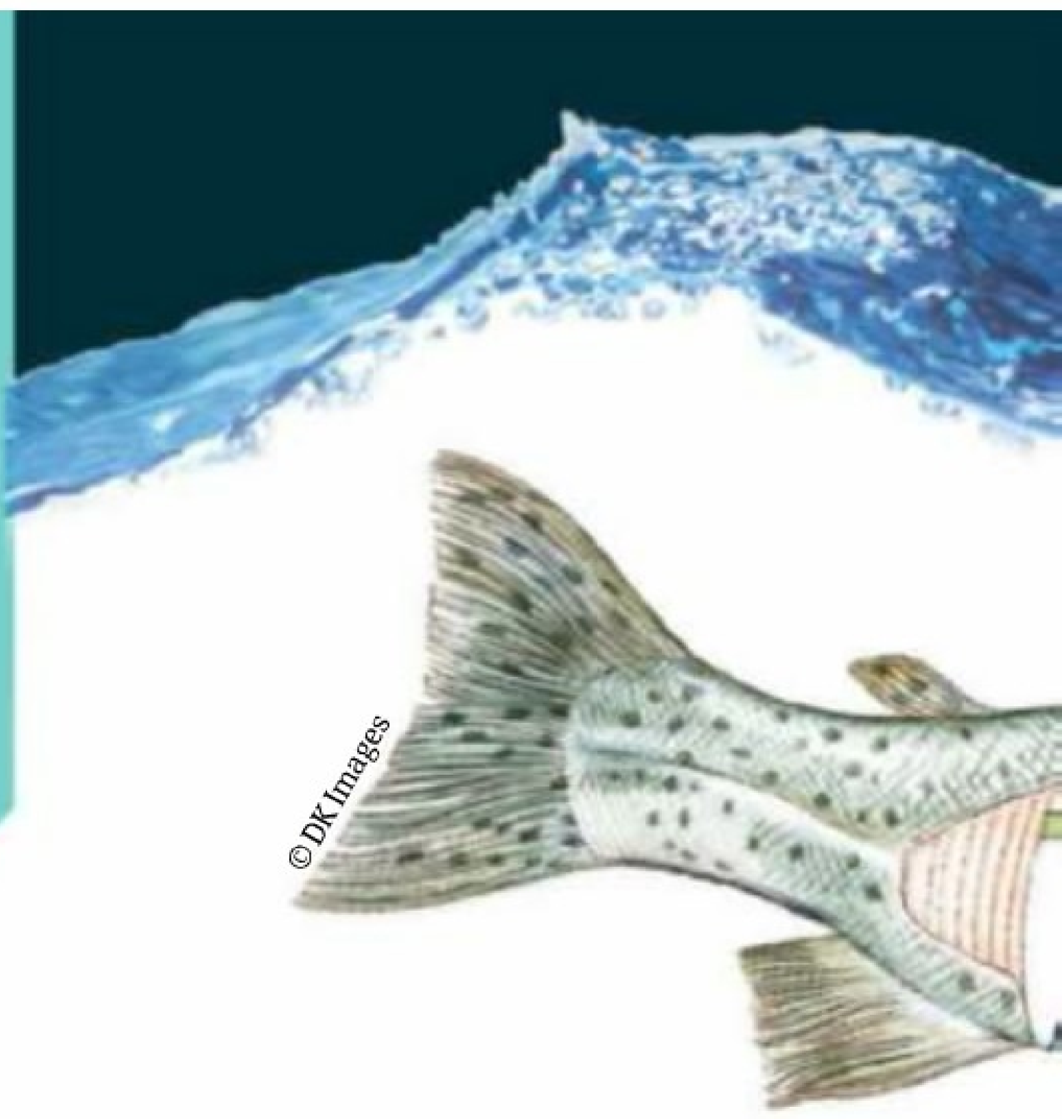
Geoduck clam
A kind of saltwater clam that's able to live for well over 100 years.

Ninja slug
This gastropod injects aphrodisiac darts into potential passing mates.

Pink fairy armadillo
The smallest species of armadillo can 'swim' under desert sand.

Snub-nosed sneezing monkey
Due to its upturned hooter, rain often gets in and makes it sneeze.

SEA LIFE


© DK Images

Sharks
034

046 Lionfish

© Jens Peterson

Coral reefs
056

047 Pufferfish

Sea life

034 **Sharks! 50 incredible facts**
The ultimate underwater predator

042 **Shark attacks**
Great white hunting habits

043 **Tonic immobility**
Feigning death to live another day

043 **Swim bladders**
How fish remain buoyant

044 **Schooling fish**
Inside massive shoals of fish

046 **Cuttlefish**
Colour-changing molluscs

046 **Lionfish**
Lightning fast with toxic spines

047 **Pufferfish**
Ballooning defences

048 **Anglerfish**
Deep-sea fisher with rod and lure

048 **Stonefish**
The deadliest fish on the seabed

049 **Archerfish**
Sneaky with the water pistol

049 **Stingrays**
Flat cousins of the sharks

049 **Seahorses**
Tiny, bony, equine fish

050 **Octopuses**
Eight-legged wonders

052 **Giant squid**
Half-ton monsters

052 **Squid swimming**
Jet propulsion for squid

053 **Mantis shrimp**
The world's fastest punch

053 **Pistol shrimp**
Sonic bubble shooters

054 **Coconut crabs**
Tree-climbing crabs

054 **Barnacles**
Steady as a rock

055 **Box jellyfish**
Stunningly poisonous

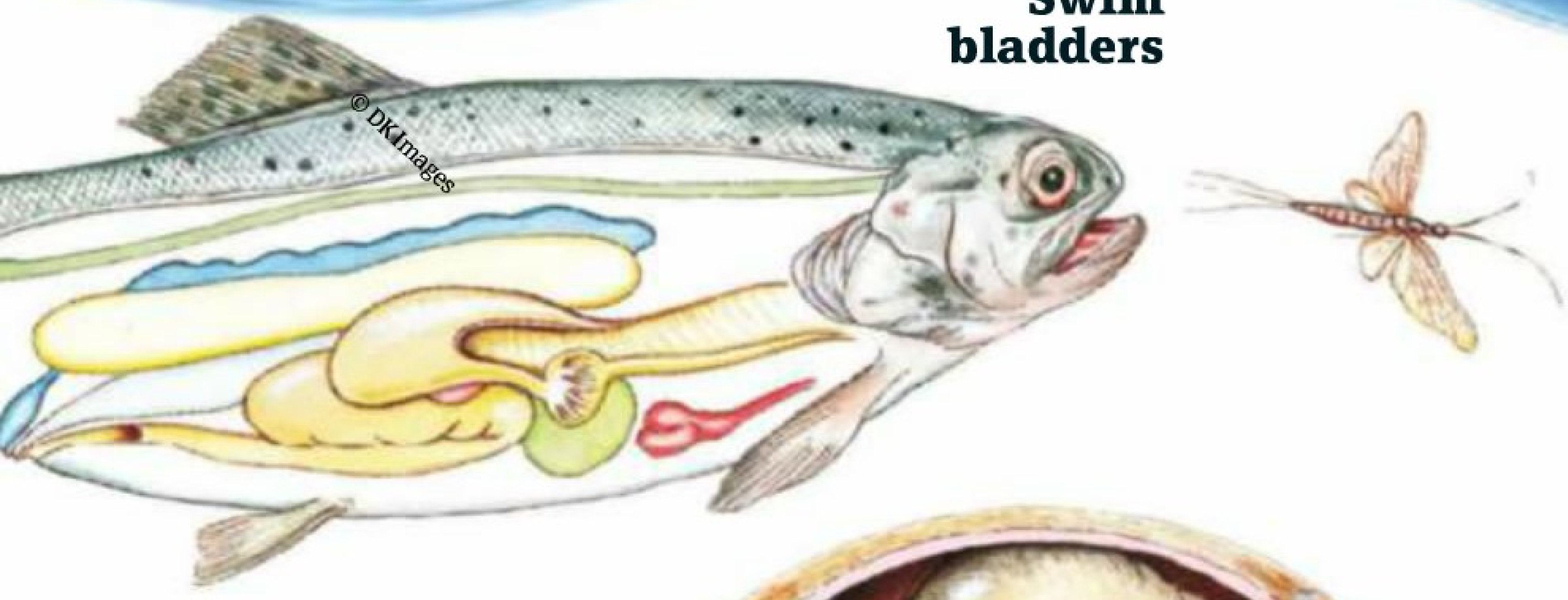
055 **Jellyfish life cycle**
From sperm to medusa

056 **Coral reefs**
Rainforests of the ocean

061 **Starfish**
Carnivorous stars

061 **Regeneration**
No prosthesis necessary

062 **Rock pools**
More than just seaweed



043
Swim bladders

© DK Images

Coconut crabs
054

© DK Images

050
Octopuses

Great Barrier Reef
059

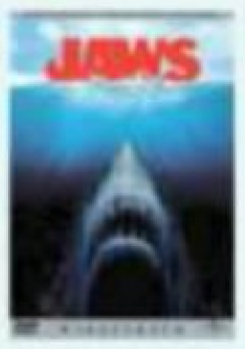
© Jon Hanson, 2005

Mantis shrimp
053

SHARKS!

50 INCREDIBLE FACTS ABOUT THE PLANET'S MOST EXTREME UNDERWATER PREDATOR

Head to Head
BIGGEST SHARK FILMS



MOST CELEBRATED

1. Jaws

After a gigantic great white shark goes on a killing spree, a police chief, marine scientist and experienced fisherman set sail to stop it, with explosive and gory results.

MOST DERIDED

2. Shark Attack 3

Despite being extinct for over 24 million years, megalodon returns in this widely condemned B-movie to wreak gory havoc. Can no one stop its reign of terror?

MOST STUPID

3. Mega Shark vs Giant Octopus

When a colossal shark and octopus have a royal rumble off the coast of California, only scientist Emma MacNeil can save the Earth.

DID YOU KNOW? You are roughly twice as likely to die from a coconut falling on your head than a shark bite

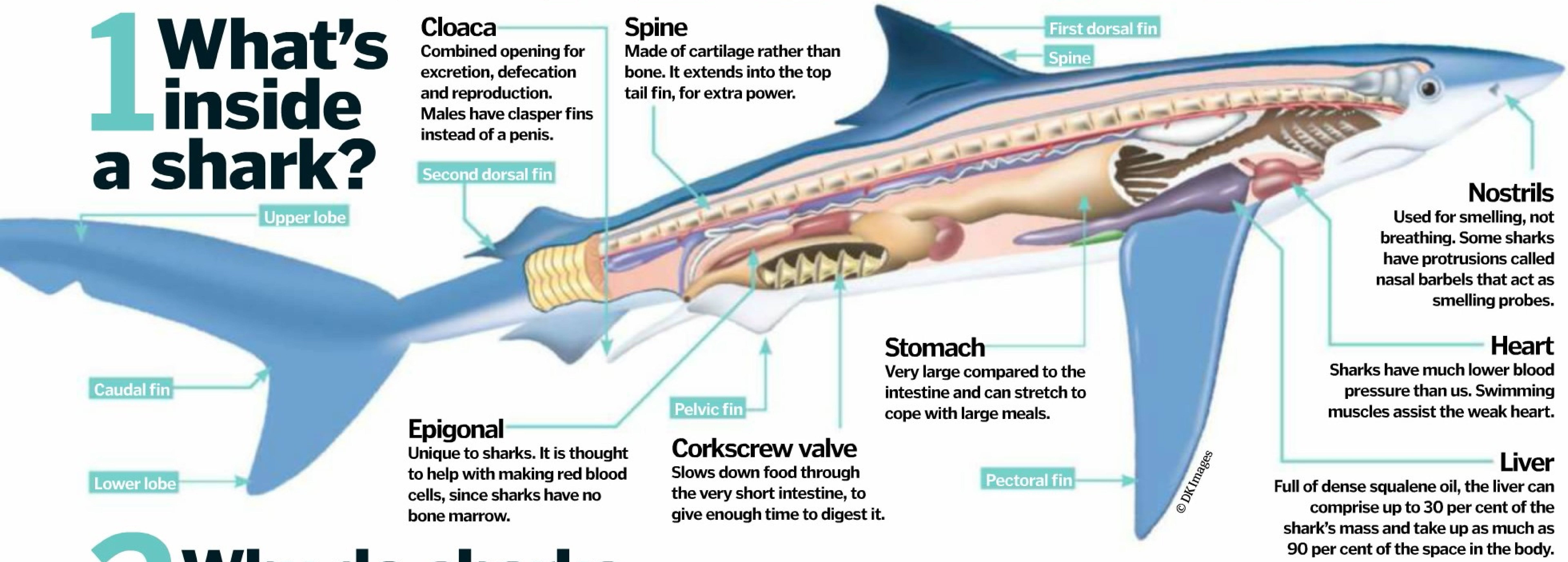
SHARK ANATOMY

Nearly every stereotype of the shark is wrong. They aren't primitive animals, they aren't mindless killing machines and they don't prey on humans. Sharks are elasmobranchs, meaning that they are fish that have cartilage skeletons instead of bones. Far from being an evolutionary leftover, however, this evolved to save weight so that large sharks could still be fast and agile swimmers. Cartilage also lets sharks conserve calcium and phosphorous, which is important because they need both for making teeth. And they get through a *lot* of those. Sharks treat their teeth as disposable weapons and can lose a couple with every bite. In fact, sharks get through so many teeth in their lifetime that the availability of the mineral phosphorous was historically the biggest constraint on their spread around the world.

Sharks haven't always been objects of fear. Victorian sailors regarded them as entirely benign – like dolphins. Then in 1916, along the coast of New Jersey, four people were killed and one badly injured in a spate of unprovoked attacks by sharks. This sparked a media frenzy that inspired the 1974 novel *Jaws* by Peter Benchley, and sharks have been the villains of the sea ever since. Despite the fact that you are roughly twice as likely to die from a coconut landing on your head than a shark bite, we still have a grossly inflated sense of the threat these creatures pose. Sharks are apex predators and very well adapted for hunting in the sea, but the fact remains that for every human eaten by a shark, 20 million sharks are eaten by humans.

Sharks were once regarded as benign by sailors

1 What's inside a shark?



Cloaca
Combined opening for excretion, defecation and reproduction. Males have clasper fins instead of a penis.

Spine
Made of cartilage rather than bone. It extends into the top tail fin, for extra power.

Nostrils
Used for smelling, not breathing. Some sharks have protrusions called nasal barbels that act as smelling probes.

Heart
Sharks have much lower blood pressure than us. Swimming muscles assist the weak heart.

Stomach
Very large compared to the intestine and can stretch to cope with large meals.

Epigonal
Unique to sharks. It is thought to help with making red blood cells, since sharks have no bone marrow.

Corkscrew valve
Slows down food through the very short intestine, to give enough time to digest it.

Liver
Full of dense squalene oil, the liver can comprise up to 30 per cent of the shark's mass and take up as much as 90 per cent of the space in the body.

2 Why do sharks have so many fins?

They don't really have many more fins than other fish, it's just that they are larger and more conspicuous. Sharks use their wide pectoral fins to generate lift, like the wings of a plane. The tail, or caudal fin, has a larger upper lobe because the spine extends into it. This generates thrust and the notches reduce turbulence. The dorsal and anal fins reduce the amount of side-to-side motion as the tail beats. The second dorsal fin is the only one missing from other fish and it offsets the movement of the large upper caudal lobe.

> "Sharks treat their teeth as disposable weapons and can lose a couple with every bite"

SHARK BITES

6 DO SHARKS HAVE TONGUES AND A SENSE OF TASTE?

The basihyal looks a bit like a tongue, but it is really just a protrusion of cartilage on the floor of the mouth. Sharks have tastebuds on the rest of their mouth, though, and often give prey a test bite to check the flavour.

7 HOW CAN YOU TELL A SHARK'S GENDER?

Male sharks have a pair of protrusions called claspers on their belly, between the pelvic fins. These are used like a penis to insert into the female's cloaca.

© Jlencion

8 HOW DO SHARKS HEAR?

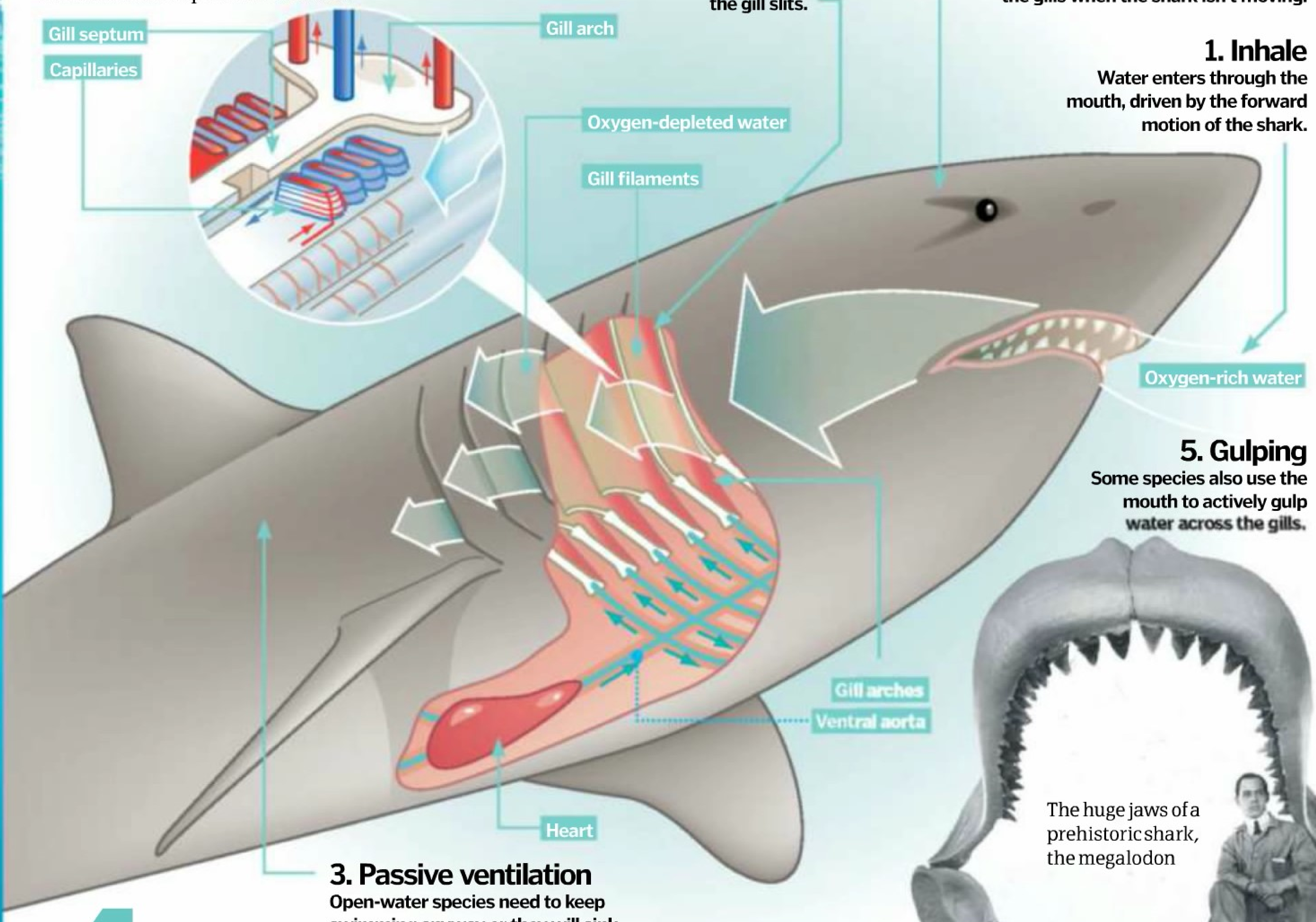
A small opening on each side of the head leads to the inner ear. Sharks have very good hearing that is tuned to lower frequencies than our ears. They can hear fish struggling from several miles away.

9 HOW DO YOU TELL THE AGE OF A SHARK?

It's not easy. Because they shed their teeth so often, you can't measure the growth rings in them to determine age. The vertebrae have growth rings too, but they aren't added at a uniform rate, so researchers inject marker chemicals to captured sharks to provide reference samples.

3 If a shark stops swimming does it drown?

Yes. It's essential that sharks keep moving in order to get enough water across their gills to breathe. Find out more about shark respiration below…



2. Gill slits
It passes over the gill bars and exits through the gill slits.

4. Spiracle
Bottom-dwelling sharks have an opening behind the eye that can pump water over the gills when the shark isn't moving.

1. Inhale
Water enters through the mouth, driven by the forward motion of the shark.

5. Gulping
Some species also use the mouth to actively gulp water across the gills.

3. Passive ventilation
Open-water species need to keep swimming anyway or they will sink, so this system works fine.

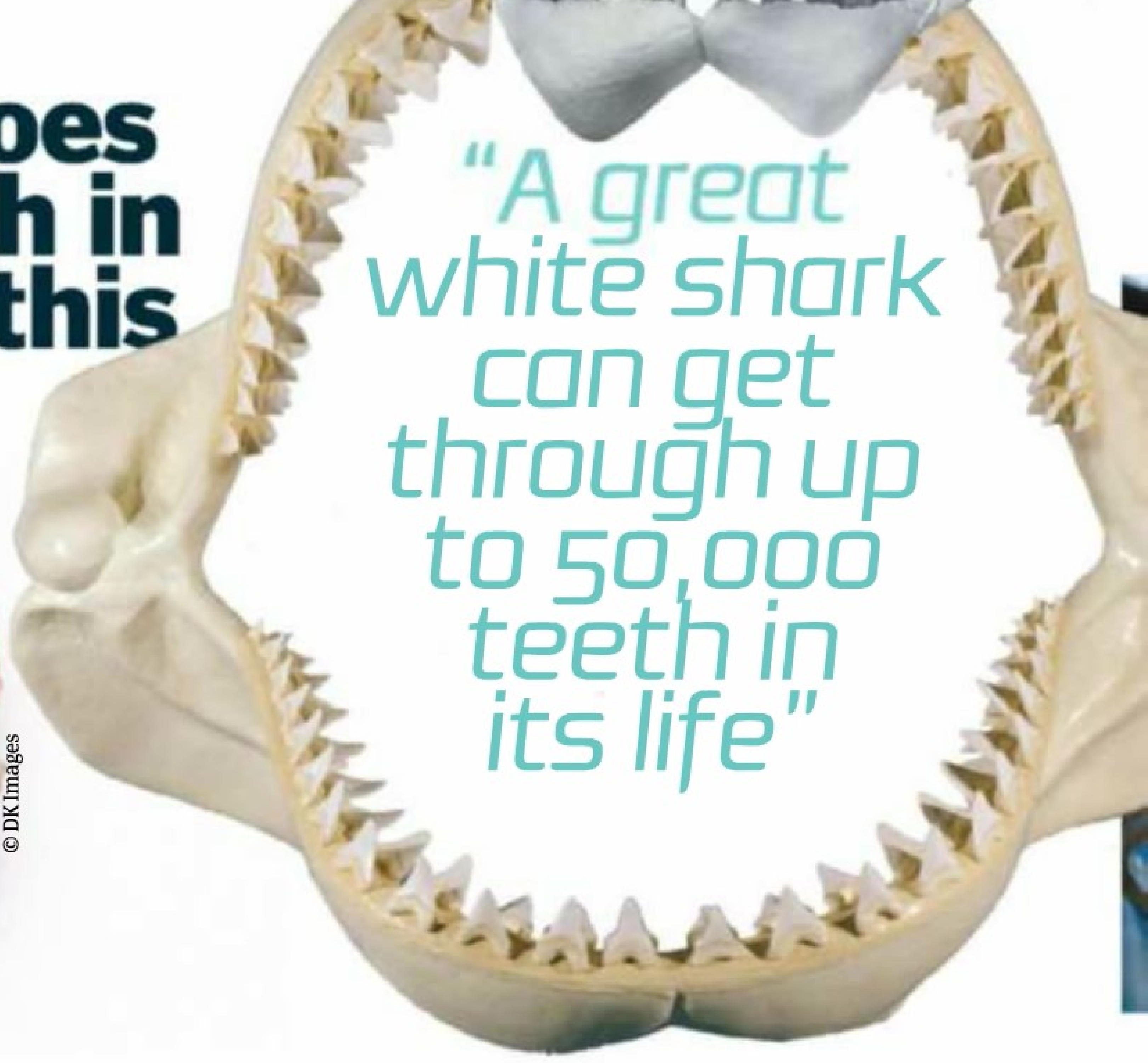
The huge jaws of a prehistoric shark, the megalodon

4 How many teeth does a shark get through in a lifetime? Why is this number so high?

Shark teeth aren't embedded in the jaw, but are attached to the skin. They are designed to be disposable and are continually replaced like a conveyor belt from the back of the mouth. A great white shark can get through up to 50,000 teeth in its lifetime.

© DK Images

Growth
Layers of razor-sharp, serrated teeth roll forward to replace broken or missing ones.



> "A great white shark can get through up to 50,000 teeth in its life"

Head to Head BIGGEST SHARKS

1. Great white shark
The great white shark (carcharodon carcharias) is actually not the largest. The largest example found to date measured 7.9m (26ft).

2. Basking shark
The basking shark (cetorhinus maximus) is rather large, weighing in at up to 19 tons despite being a harmless filter feeder.

3. Whale shark
Measuring in at over 12.8m (42ft) in exceptional cases, the whale shark (rhincodon typus) is the largest on the planet; they can live for up to 70 years.

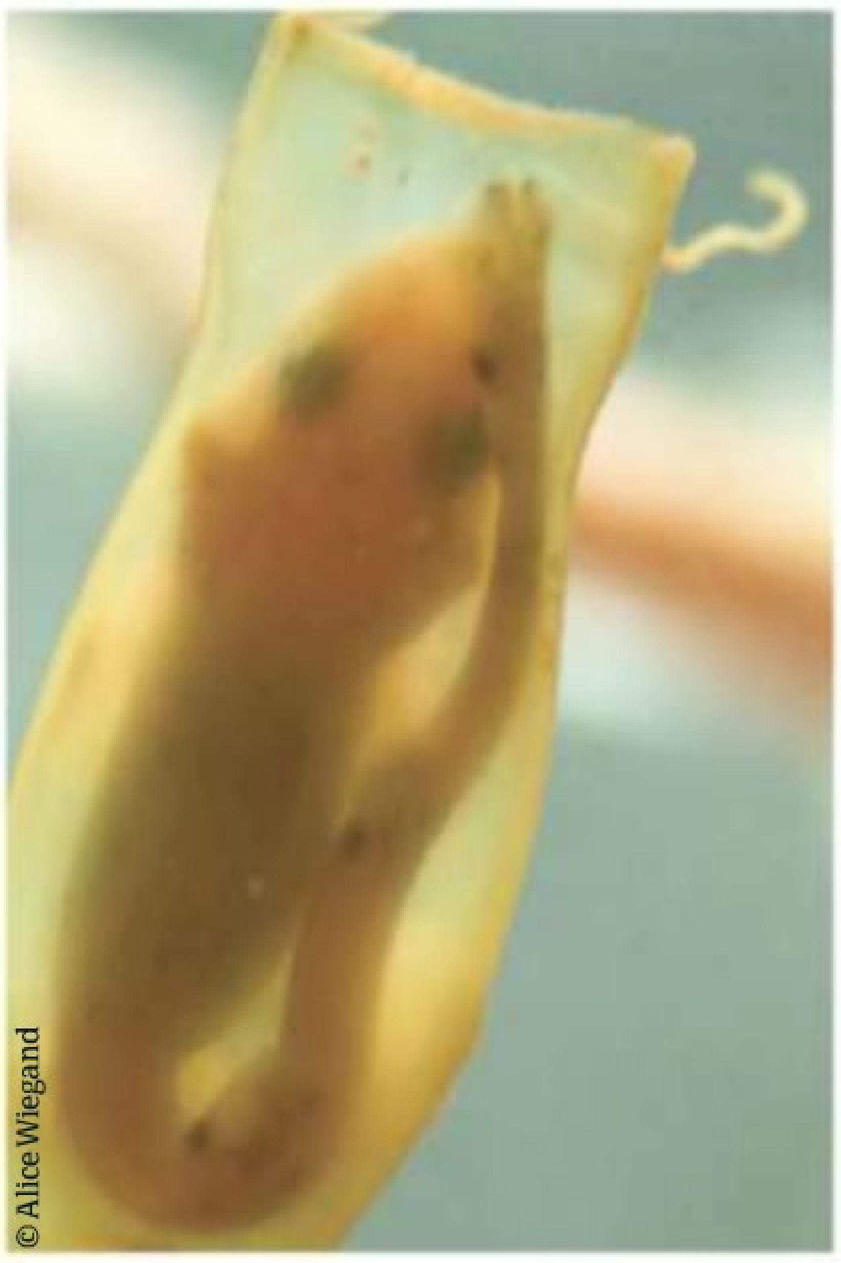
DID YOU KNOW? *Open-water species have to keep swimming or they will sink*

All the participants in the ancient Olympics, for the first several centuries of the competition, were aristocrats

5

How do sharks give birth, and what are 'mermaid's purses'?

Most sharks retain their eggs inside the female and give birth to live young. A few species, including the horn shark and Port Jackson shark lay eggs inside a leathery egg case. Empty egg cases that wash up on the shore are called mermaid's purses.


© Alice Wiegand

(Above) Some sharks lay eggs inside a case; (Below) Shark skin scales resemble tiny teeth

10 DO SHARKS HAVE BONES?

No. Sharks belong to the elasmobranch group of fish that have lighter, more flexible cartilage in their skeleton, instead of bone. Their muscles are anchored directly to the inside of their tough skin.

11 HOW DO SHARKS STAY BUOYANT?

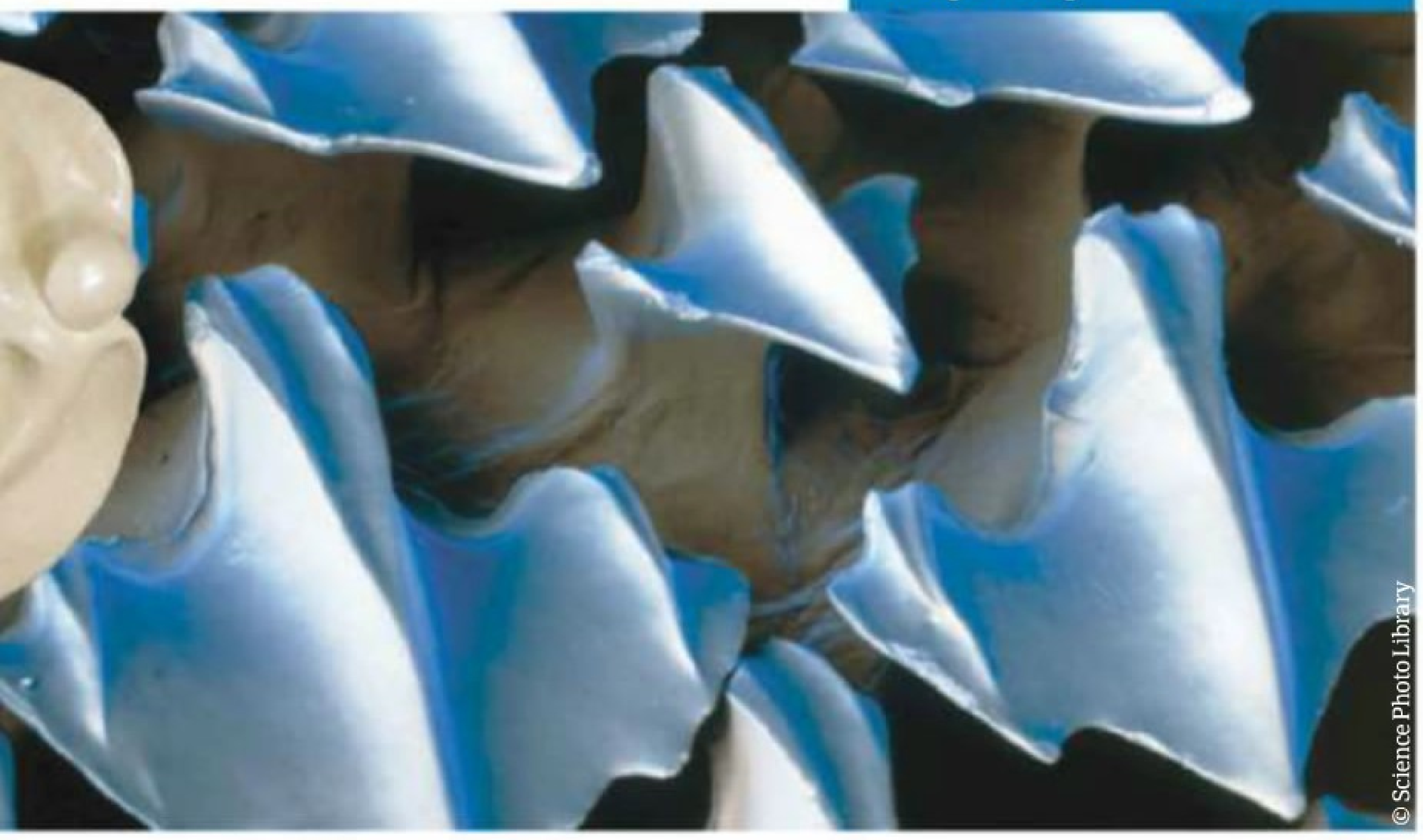
Sharks don't have a swim bladder like other fish, so they use their liver instead. The amount of squalene oil stored there is adjusted to leave the shark slightly heavier than water. The extra buoyancy is supplied by dynamic lift from the shark's fins as it swims.

12 HOW GOOD IS A SHARK'S EYESIGHT?

Sharks have good night vision and can contract and dilate their pupils, which bony fish cannot do. Sharks are either colour-blind or can see only shades of grey and green.

13 DOES A SHARK'S SKIN HELP IT SWIM FASTER?

Shark skin is covered with scales like other fish, but shark scales are made from dentine and actually resemble tiny teeth more than scales. These 'dermal denticles' generate tiny vortices on their trailing edges as the shark swims and this vastly reduces the shark's drag through the water.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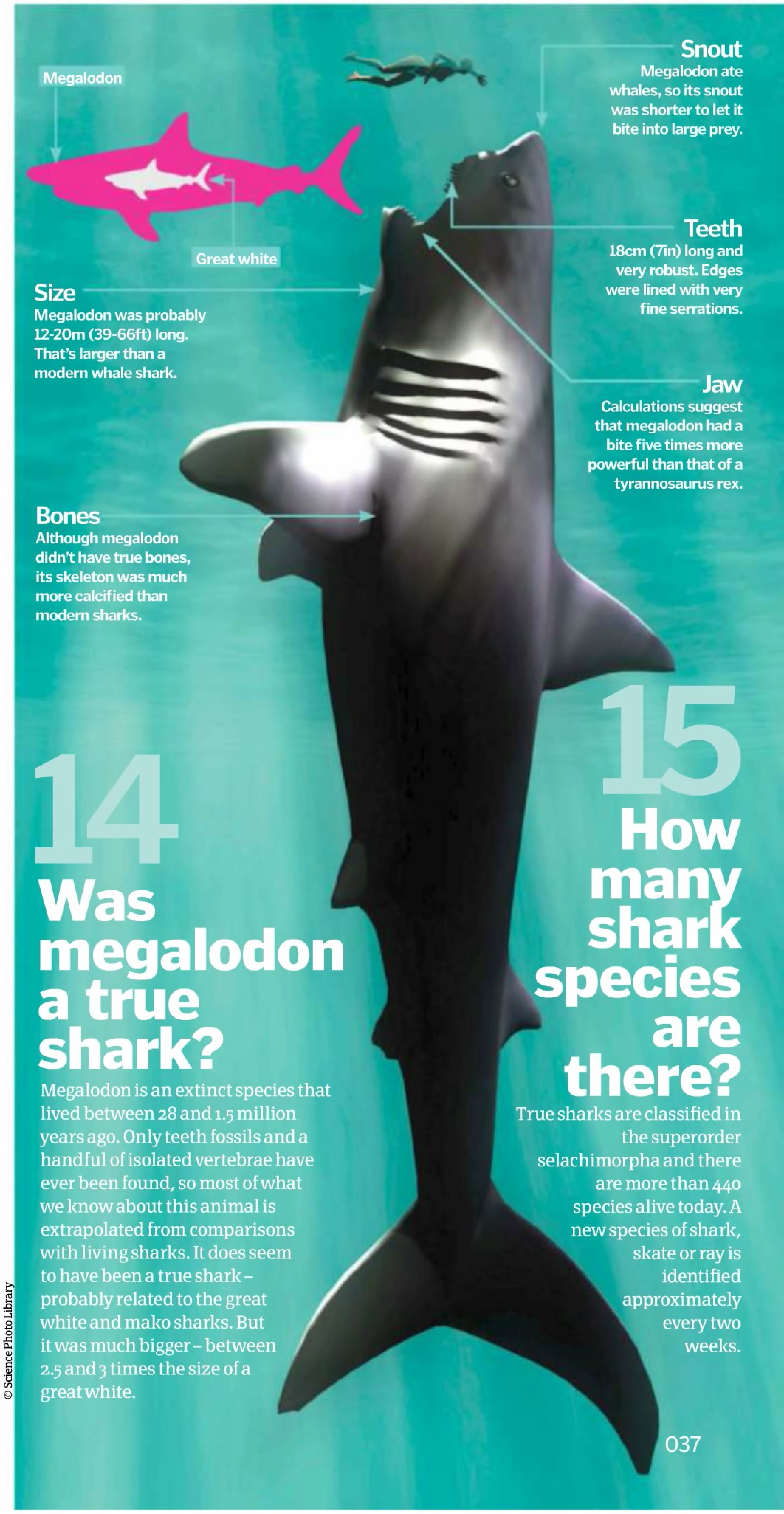
SPECIES



Snout
Megalodon ate whales, so its snout was shorter to let it bite into large prey.

Teeth
18cm (7in) long and very robust. Edges were lined with very fine serrations.

Size
Megalodon was probably 12-20m (39-66ft) long. That's larger than a modern whale shark.

Jaw
Calculations suggest that megalodon had a bite five times more powerful than that of a tyrannosaurus rex.

Bones
Although megalodon didn't have true bones, its skeleton was much more calcified than modern sharks.

© Science Photo Library

14

Was megalodon a true shark?

Megalodon is an extinct species that lived between 28 and 1.5 million years ago. Only teeth fossils and a handful of isolated vertebrae have ever been found, so most of what we know about this animal is extrapolated from comparisons with living sharks. It does seem to have been a true shark – probably related to the great white and mako sharks. But it was much bigger – between 2.5 and 3 times the size of a great white.

15

How many shark species are there?

True sharks are classified in the superorder selachimorpha and there are more than 440 species alive today. A new species of shark, skate or ray is identified approximately every two weeks.

SHARK BITES

21 HOW LONG DO SHARKS LIVE?

Most species live for between 20 and 30 years. But the whale shark is estimated to live for up to 100 years.

22 WHAT'S THE SMALLEST SPECIES OF SHARK?

A kind of deepwater dogfish shark called etmopterus perryi. It lives in the Caribbean Sea and grows no larger than 20cm (7.8in).

23 DO ANY SHARKS GLOW IN THE DARK?

Yes, a few species use bioluminescence to lure prey. The brightest is the cookie cutter shark, which glows over its entire stomach, except for a dark band round its neck. This makes it look like a much smaller fish silhouetted against the sky.

24 IS IT TRUE THAT SHARKS DON'T GET CANCER?

Sharks definitely do get cancer, but there's some evidence that a compound called angiogenin, an inhibitor in shark cartilage, reduces the ability of tumours to grow.

25 WHAT'S THE MOST ENDANGERED SPECIES OF SHARK?

Both the large sawfish and the common sawfish are listed as critically endangered by the International Union for Conservation of Nature. Their saw snouts become very easily entangled in fishing nets.

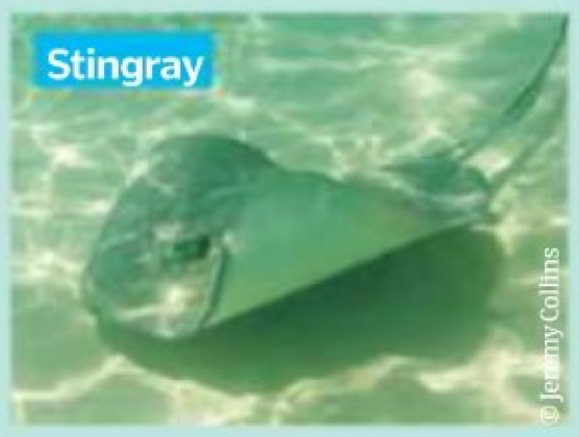
26 WHICH IS THE FASTEST SHARK EVER?

The shortfin mako shark. An open-water hunter that chases fast fish such as tuna, it can reach up to 32km/h (20mph).

16 How does a hammerhead shark know which way it's going?

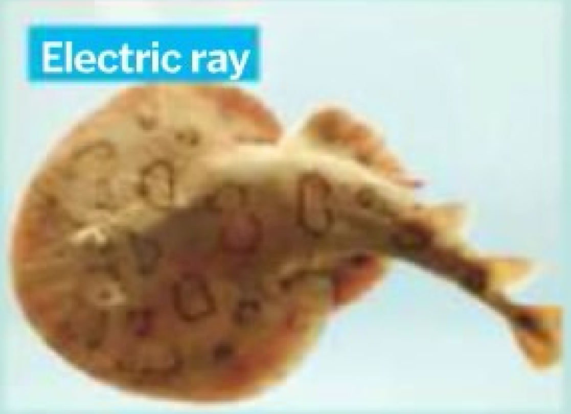
Despite their oddly shaped heads, hammerhead sharks can see forwards at least as well as other sharks, and possibly better. All fish have their eyes set on the sides of their head, but the hammer or cephalofoil on a hammerhead shark is right at the front so they have much less snout to get in the way of forward vision than other sharks. The wide separation also allows better directionality of the special electrical sense of sharks. Hammerheads eat stingrays and their electrical sense helps them find rays buried under the sand on the seabed.

17 Which ones don't look like sharks?

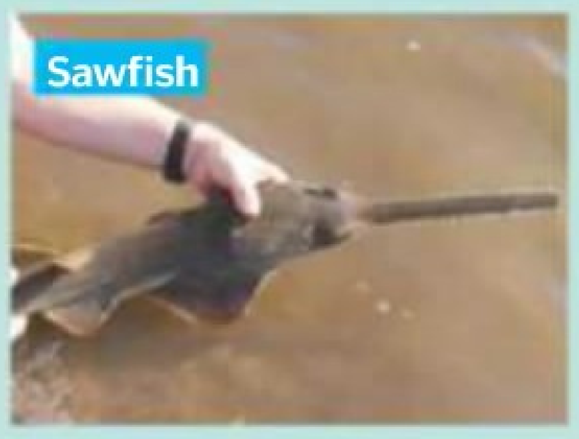


Stingray

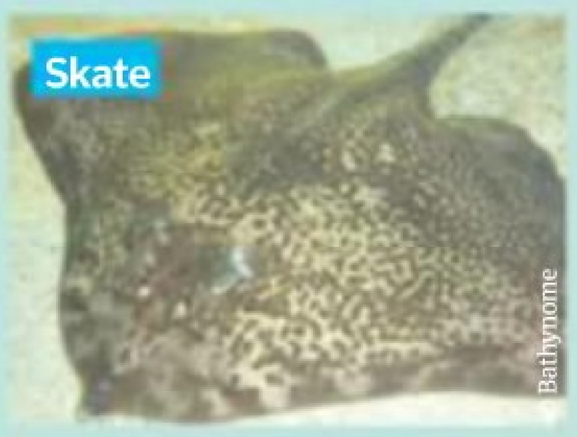
© Jeremy Collins



Electric ray

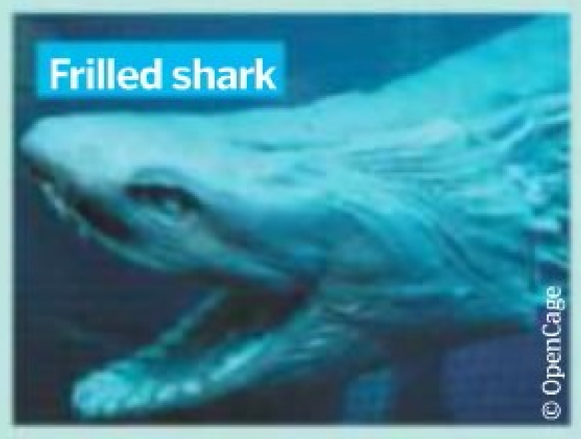


Sawfish



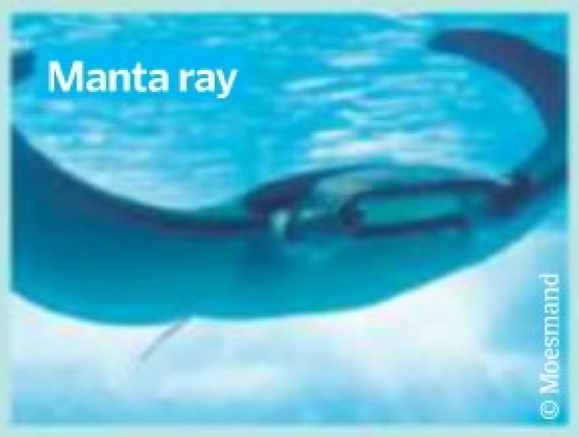
Skate

Bathynome



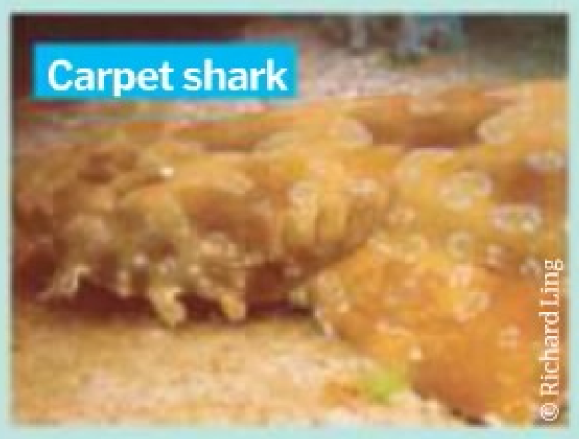
Frilled shark

© OpenCage



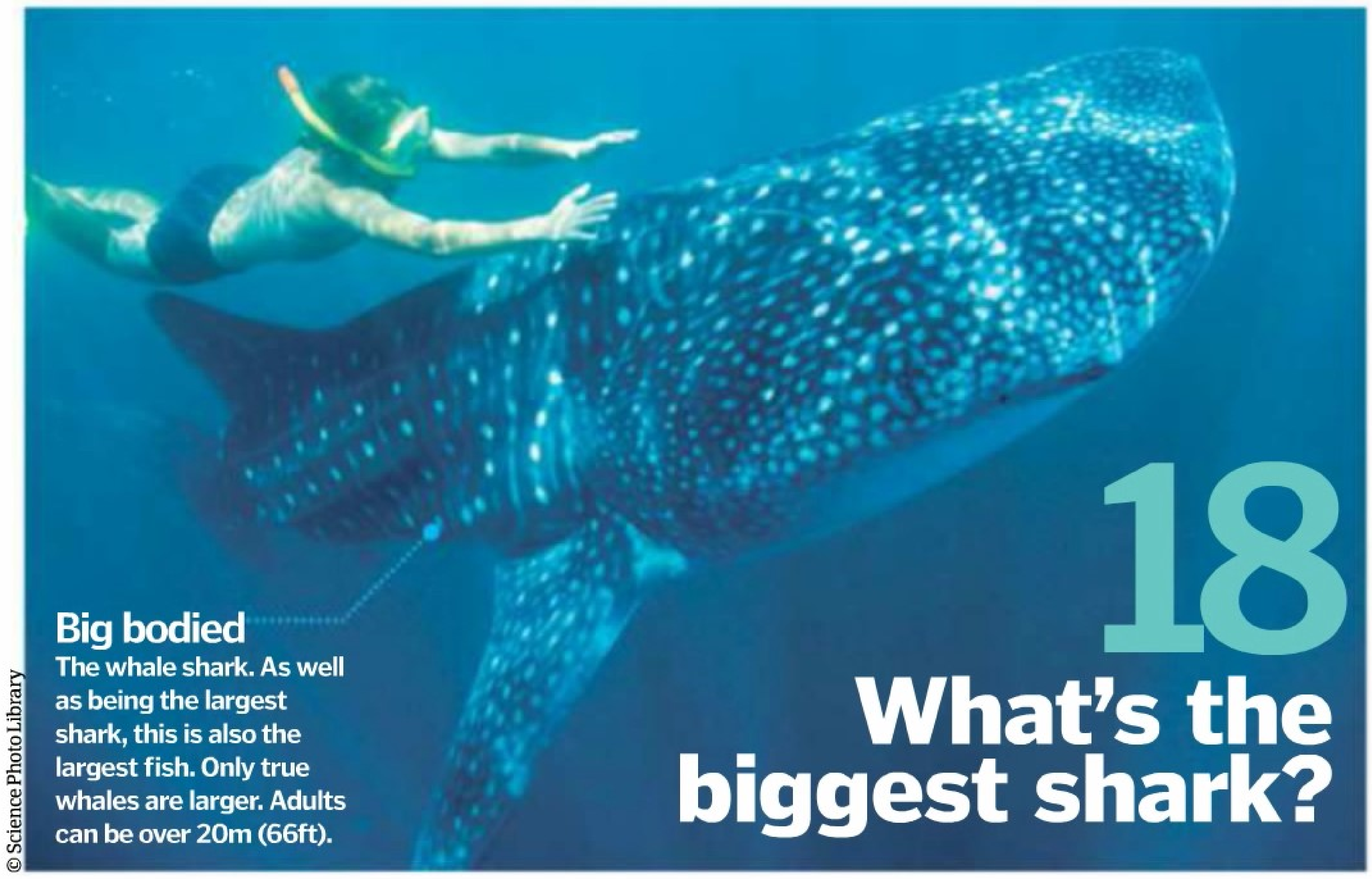
Manta ray

© Moesmand



Carpet shark

© Richard Ling



Big bodied The whale shark. As well as being the largest shark, this is also the largest fish. Only true whales are larger. Adults can be over 20m (66ft).

© Science Photo Library

18 What's the biggest shark?

19 What is the deadliest shark?

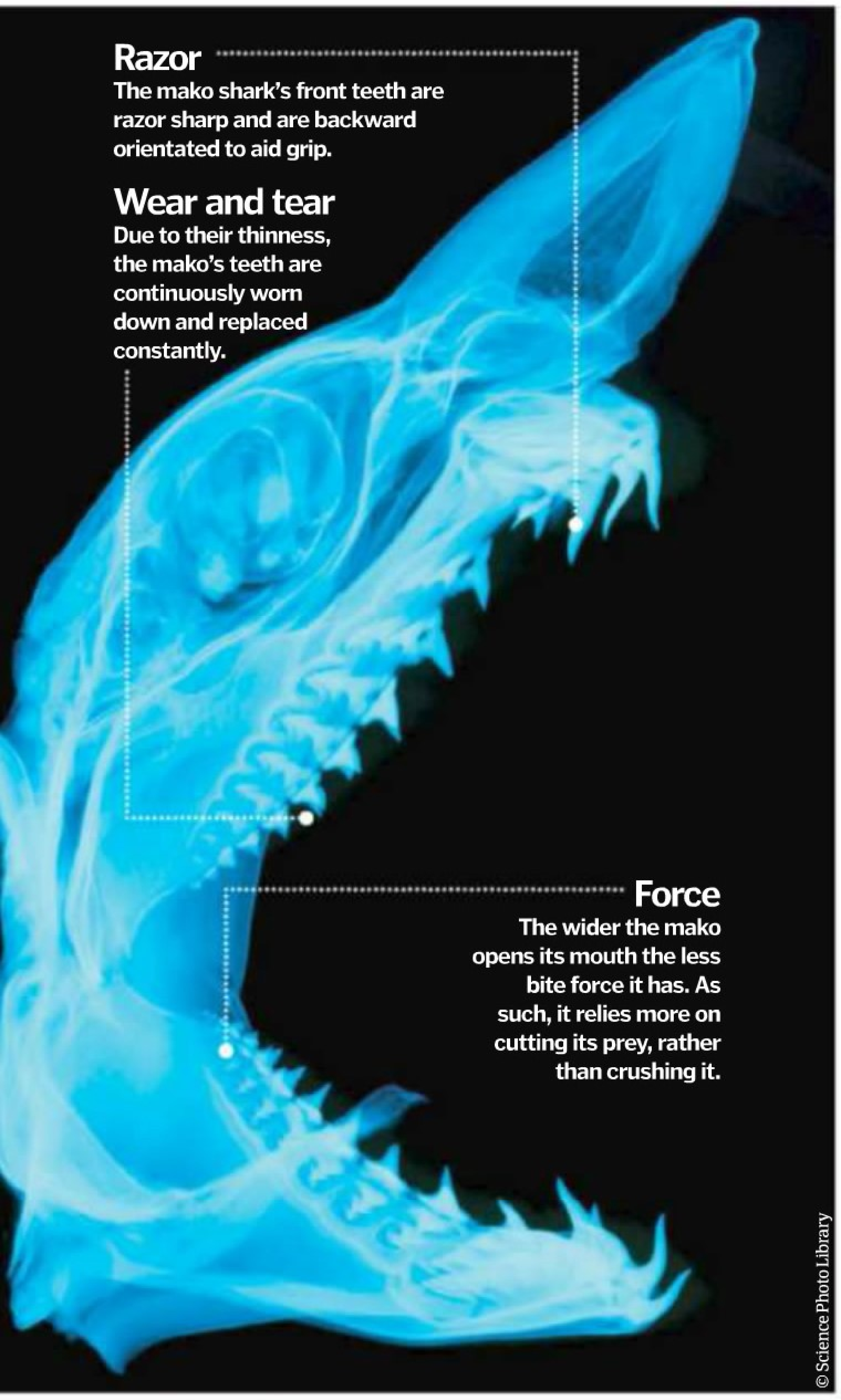
The International Shark Attack File keeps records going back to the 16th century and shows that the tiger, bull and great white between them account for 99 per cent of shark attacks on humans. Of these, the great white tops the list with 249 unprovoked attacks and 65 fatalities.

20 What's the oldest shark on record?

Modern sharks date back around 100 million years, but there were primitive sharks as long ago as 420 million years. One of the earliest was cladoselache, which lived around 370 million years ago. Very well preserved fossils show skin, muscles and even some internal organs. Apart from a few around the mouth and the fins, cladoselache had no scales. Its teeth were smooth and it swallowed its prey whole.

DID YOU KNOW? *100 million sharks are killed every year by humans. Five humans are killed every year by sharks*

BEHAVIOUR



Razor
The mako shark's front teeth are razor sharp and are backward orientated to aid grip.

Wear and tear
Due to their thinness, the mako's teeth are continuously worn down and replaced constantly.

Force
The wider the mako opens its mouth the less bite force it has. As such, it relies more on cutting its prey, rather than crushing it.

© Science Photo Library

27 How powerful are shark jaws?

A six-metre shark, such as a great white, can exert more than 18,000 newtons of force with a bite. That's a huge force – twice as much as the largest alligators, which have the strongest bite of any land animal, and more even than current estimates of the bite of the T-rex. But it doesn't end there. An alligator only exerts maximum bite force when its jaws are almost shut. The wider it opens its mouth, the less leverage is available for the jaw muscles and the weaker the bite becomes. Great white sharks have a unique arrangement of muscles in their jaw that enables them to exert maximum bite force, regardless of how wide their mouth is opened.

28 How smart are sharks?

Sharks have a similar ratio of brain to body mass as that in most mammals and birds. They certainly aren't mindless killing machines. Seven great white sharks were observed in 1987 off the coast of South Africa, co-operating to refloat a dead, beached whale so that they could eat it. When great whites hunt dolphins, they approach from above and behind, to prevent the dolphin using its echolocation sense to detect the shark.

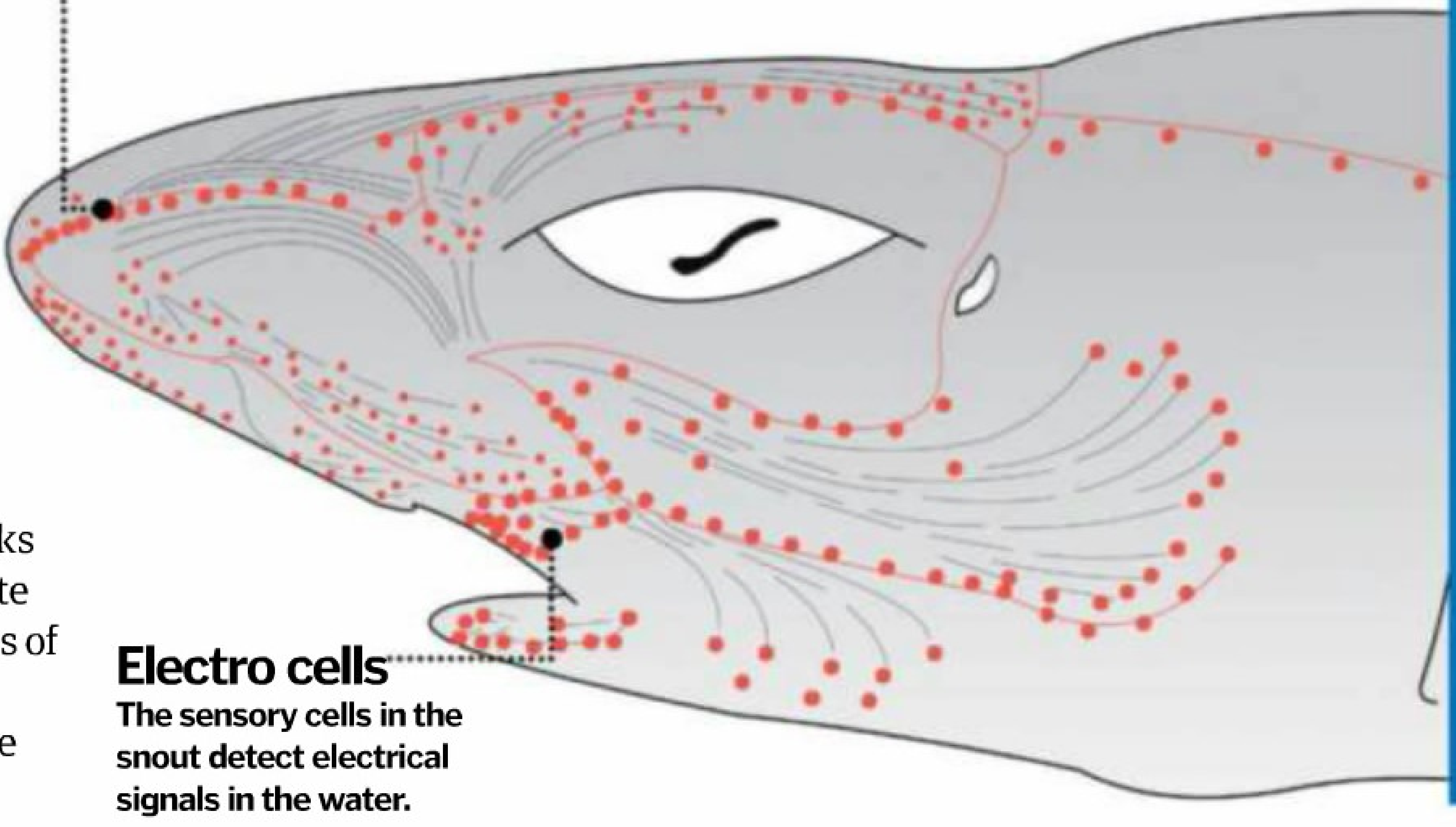
29 What are the weirdest items found in a shark?

- Ladies' pyjamas
- A rubber tyre
- A roll of chicken wire
- Tar paper
- A bag of potatoes
- Odd shoes
- A dog
- A can of Spam
- A sack of coal
- The head and forequarters of a crocodile

(All found in the stomachs of tiger sharks, which are the most indiscriminate feeders.)

30 Do sharks use electricity to sense their prey?

Sharks have an arrangement of jelly-filled pores, concentrated around the head. These are called ampullae of Lorenzini and they allow the shark to detect electromagnetic fields. As well as giving sharks an internal compass, this lets them detect the minute electrical fields produced by the muscle contractions of all living animals. A few fish and other animals can also sense electrical fields, but sharks have by far the most sensitive version of this sixth sense.



Ampullae of Lorenzini
These jelly-filled sacs in the head help the shark locate prey.

Electro cells
The sensory cells in the snout detect electrical signals in the water.

31 DO SHARKS SLEEP?

Not properly. Some species rest on the seabed, but their eyes will still follow nearby swimmers. Others may rest one half of their brain at a time, like dolphins do. The spiny dogfish uses its spine to co-ordinate swimming, so that it can rest its entire brain without stopping.

32 ARE SHARKS SOLITARY OR DO THEY LIVE IN GROUPS?

Many species are highly social. Scalloped hammerheads can form schools of up to 100 sharks, for example. Even the normally solitary hunting species can congregate in groups around a rich food source or to breed.

33 DO SHARKS EVER ATTACK/PREY ON OTHER SHARK SPECIES?

Most shark species have fairly specific diets – blue sharks mainly eat squid, for example. But great whites, tiger sharks and mako sharks will eat tuna, seals, sea lions, dolphins and even smaller shark species. Hammerhead sharks dine almost exclusively on rays, which are closely related to sharks.

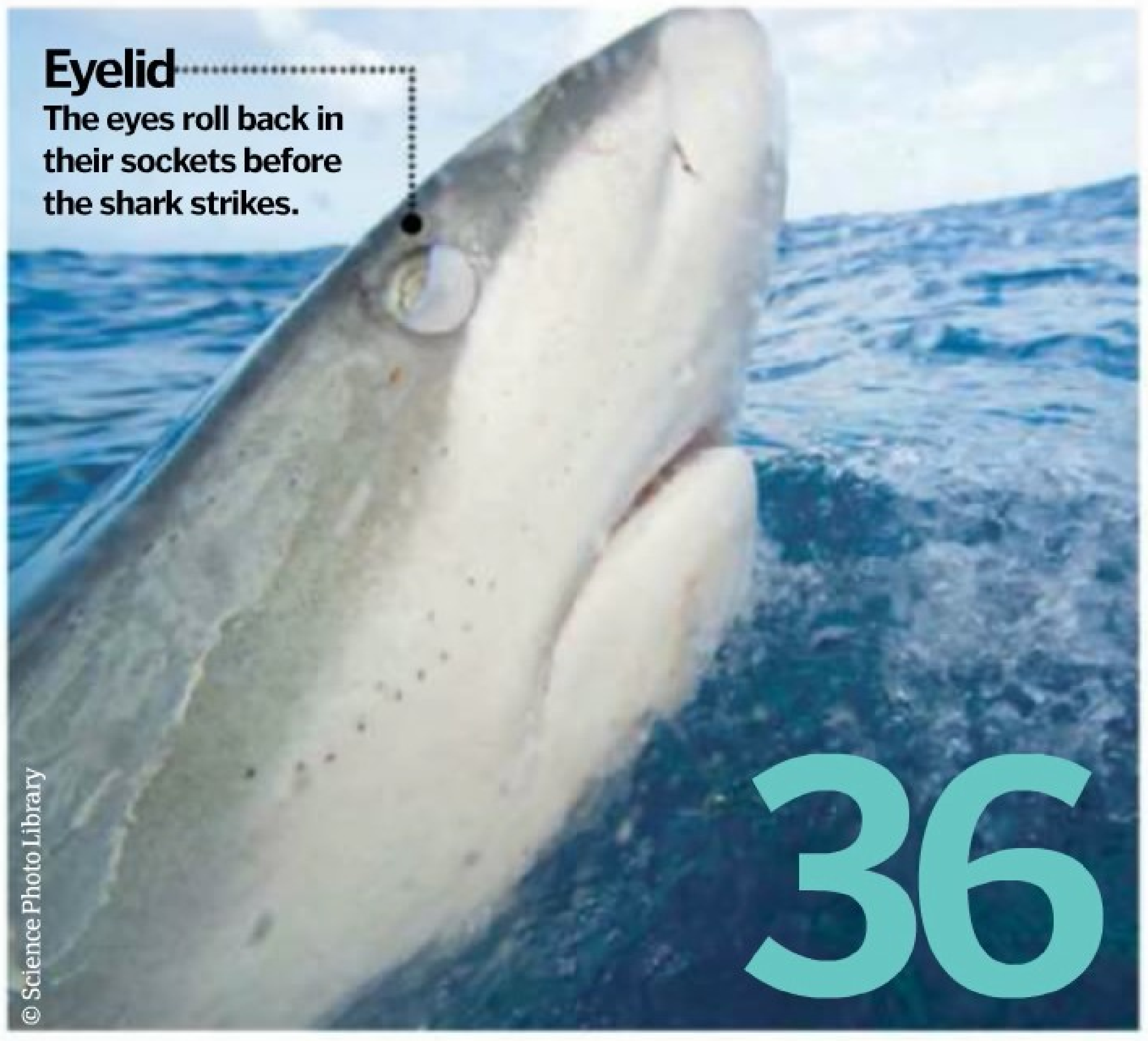
34 DOES ANY OTHER ANIMAL PREY ON SHARKS?

Orca (killer whales) have been known to attack and kill great white sharks, and sperm whales are also occasionally believed to kill sharks. These are exceptions, though. Most of the time, sharks sit firmly at the top of the food chain.

35

Can sharks smell blood from miles away, and if so how?

The open-water species can detect blood at concentrations as low as one part per million, but they are even more attracted to the smell of fish guts. By comparing the timing of the scent's arrival at each nostril, they can tell its direction and quickly home in on distant prey.



Eyelid
The eyes roll back in their sockets before the shark strikes.

© Science Photo Library

36

How do sharks attack?

Only a few species of shark are solitary ambush predators – many are filter feeders or eat small fish and crustaceans on the seabed. The aggressive hunters – tiger shark, bull shark and great white – usually patrol close to the surface. They attack at dawn or dusk, when light is poor, and from above so their light-coloured bellies make them hard to spot against the sky. Some species of shark have an extra transparent eyelid (called a nictitating membrane) that can shield their eyes, but the great white does not, so it rolls its eyes back in their sockets just before its strike connects, to protect them. Very often sharks will pursue a hit-and-run technique, taking a single bite out of their prey and then retreating to allow it to bleed to death.

Great white sharks roll their eyes when they attack

© Science Photo Library

37 HOW MANY PEOPLE ARE KILLED/ATTACKED BY SHARKS A YEAR?

In the last ten years, the number of fatalities caused by sharks averages out at less than five per year, worldwide.

38 HOW MANY SHARKS ARE KILLED/ATTACKED BY PEOPLE A YEAR?

About 100 million sharks are killed every year by humans. Some of this is recreational fishing, but most is commercial. Sharks are killed for their fins for shark fin soup, and in the Australian state of Victoria, shark is the most commonly used fish in fish and chip shops.

39 IF YOU TURN A SHARK UPSIDE DOWN DOES IT GO INTO A TRANCE?

This is called 'tonic immobility' and it doesn't work with all species, but yes, lemon, nurse and bull sharks and even great whites will suddenly become paralysed when flipped on their back. This may have evolved as part of mating, to protect females from aggressive males.

40 HOW FAST CAN A SHARK SWIM?

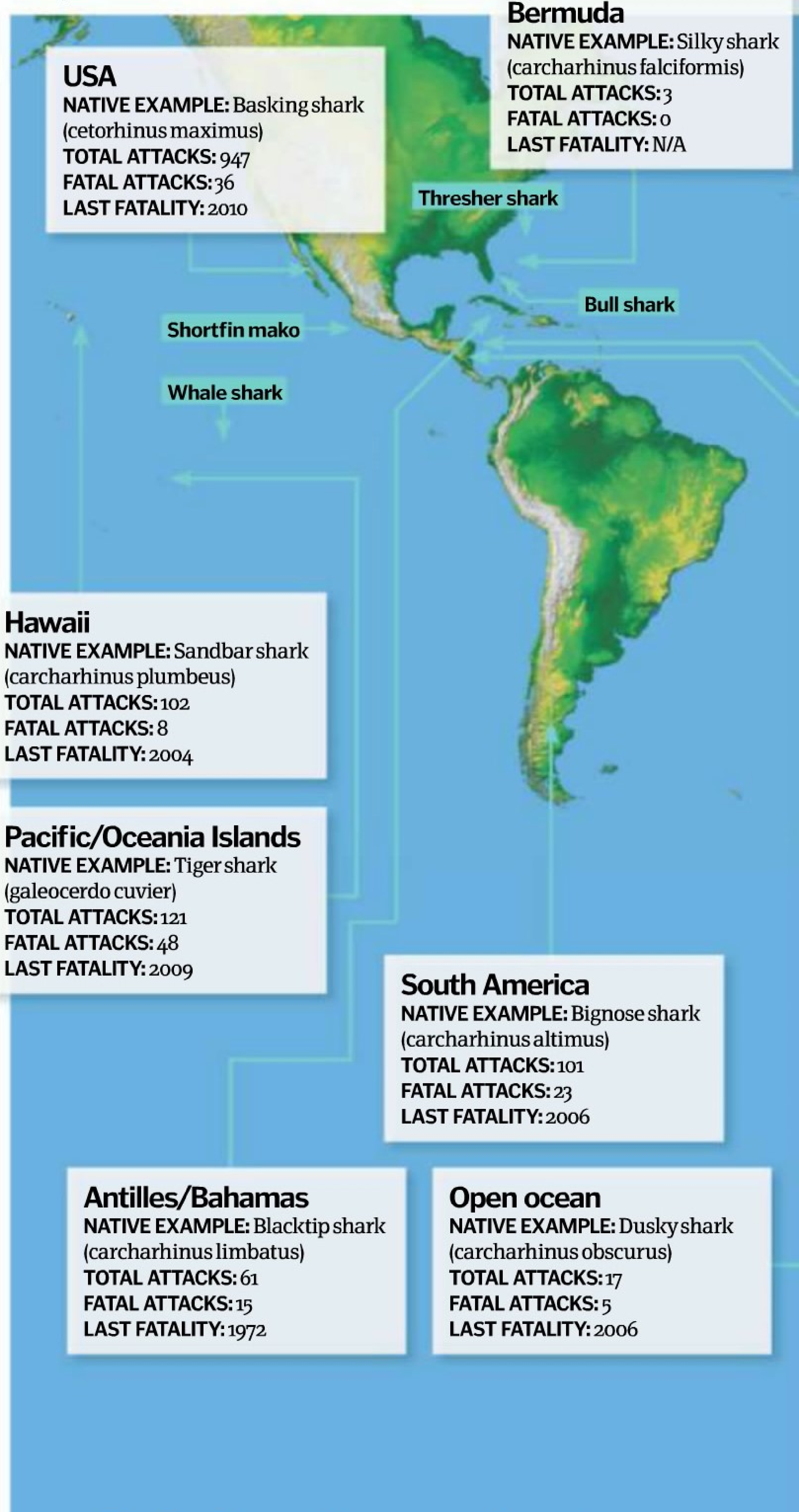
Sharks contract the muscles on their left and right sides alternately to drive their large tails sideways. This makes the head move side to side. Their rigid skin and drag-reducing dermal denticles allow them to reach speeds of up to 32km/h (20mph).

© Stormy dog

41

Statistically, what are the most deadly places on Earth with regard to shark attacks?

Between 1580 and 2010 there have been 2,320 recorded shark attacks worldwide. Here is a statistical breakdown of the most dangerous areas in the world.



© NASA

Bermuda
NATIVE EXAMPLE: Silky shark (carcharhinus falciformis)
TOTAL ATTACKS: 3
FATAL ATTACKS: 0
LAST FATALITY: N/A

USA
NATIVE EXAMPLE: Basking shark (cetorhinus maximus)
TOTAL ATTACKS: 947
FATAL ATTACKS: 36
LAST FATALITY: 2010

Hawaii
NATIVE EXAMPLE: Sandbar shark (carcharhinus plumbeus)
TOTAL ATTACKS: 102
FATAL ATTACKS: 8
LAST FATALITY: 2004

Pacific/Oceania Islands
NATIVE EXAMPLE: Tiger shark (galeocerdo cuvier)
TOTAL ATTACKS: 121
FATAL ATTACKS: 48
LAST FATALITY: 2009

South America
NATIVE EXAMPLE: Bignose shark (carcharhinus altimus)
TOTAL ATTACKS: 101
FATAL ATTACKS: 23
LAST FATALITY: 2006

Antilles/Bahamas
NATIVE EXAMPLE: Blacktip shark (carcharhinus limbatus)
TOTAL ATTACKS: 61
FATAL ATTACKS: 15
LAST FATALITY: 1972

Open ocean
NATIVE EXAMPLE: Dusky shark (carcharhinus obscurus)
TOTAL ATTACKS: 17
FATAL ATTACKS: 5
LAST FATALITY: 2006

42

Are there sharks living in every ocean on the planet?

Yes. Sharks can cope with a wide range of ocean temperatures, even within the same species. Some sharks migrate thousands of miles each year.

THE STATS GREAT WHITE SHARK

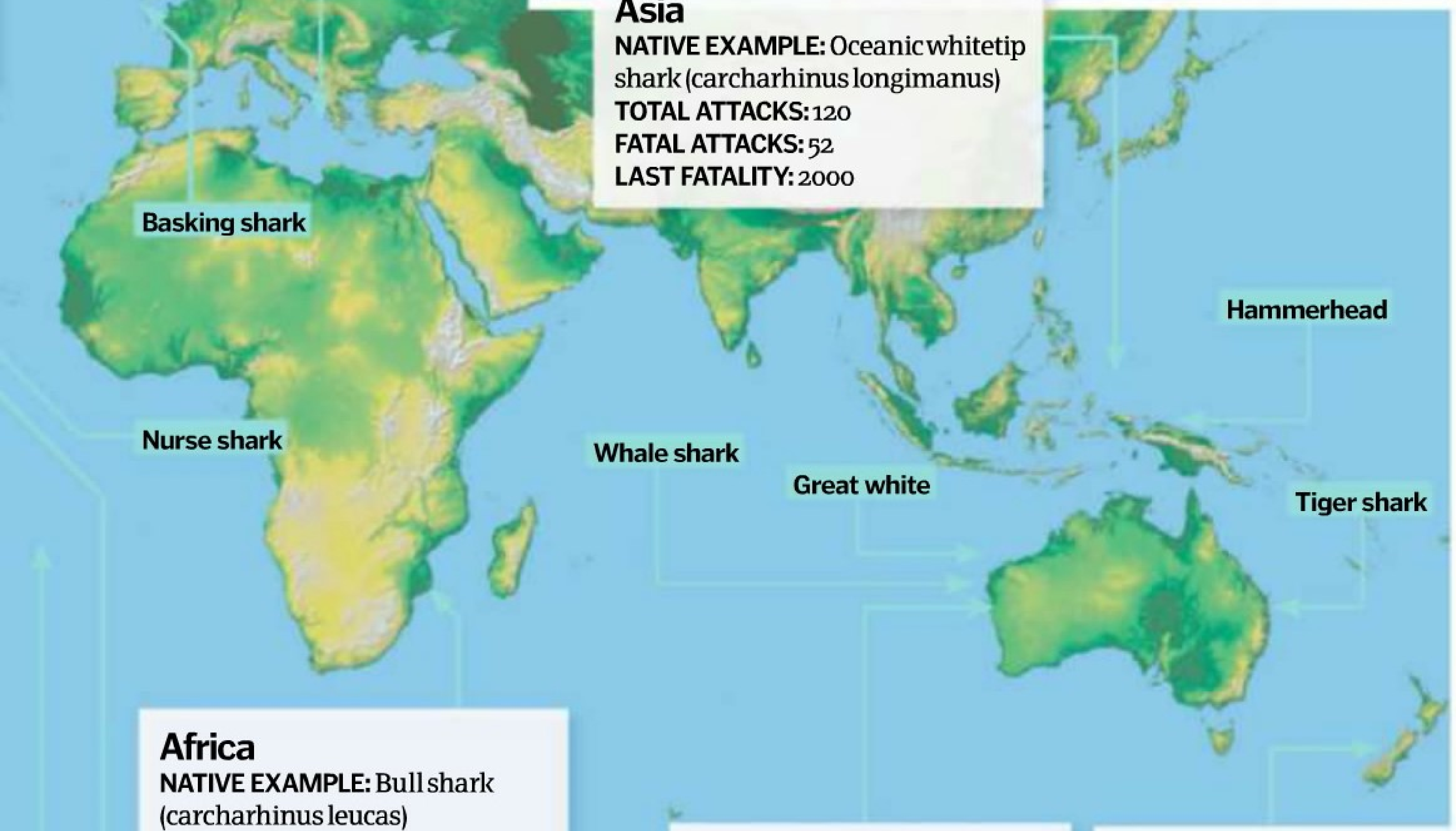
LIFE SPAN	25 years
LENGTH	4.6 metres
WEIGHT	5,000lbs
BITE FORCE	4,000lbs
NUMBER OF TEETH	3,000
TOOTH SIZE	>3 inches

DID YOU KNOW? There are over 30 species of shark native to British waters

Basking sharks are huge but generally harmless

Europe
NATIVE EXAMPLE: Porbeagle (lamna nasus)
TOTAL ATTACKS: 36
FATAL ATTACKS: 17
LAST FATALITY: 1984

Asia
NATIVE EXAMPLE: Oceanic whitetip shark (carcharhinus longimanus)
TOTAL ATTACKS: 120
FATAL ATTACKS: 52
LAST FATALITY: 2000



Africa
NATIVE EXAMPLE: Bull shark (carcharhinus leucas)
TOTAL ATTACKS: 299
FATAL ATTACKS: 78
LAST FATALITY: 2010

Australia
NATIVE EXAMPLE: Scalloped hammerhead (sphyrna lewini)
TOTAL ATTACKS: 417
FATAL ATTACKS: 131
LAST FATALITY: 2010

New Zealand
NATIVE EXAMPLE: Blue shark (prionace glauca)
TOTAL ATTACKS: 44
FATAL ATTACKS: 8
LAST FATALITY: 1968

Central America
NATIVE EXAMPLE: Great white shark (carcharodon carcharias)
TOTAL ATTACKS: 52
FATAL ATTACKS: 26
LAST FATALITY: 2008

43 What's the most common shark in British waters?

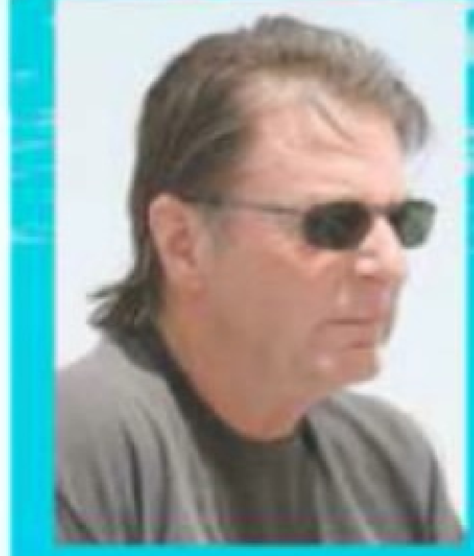
Most of the small shark species seen off the British coast are referred to collectively as dogfish. This includes the spotted dogfish and the spiny dogfish. They can reach 1-1.5m (3.3-4.9ft) in length.

44 Is there such a thing as a freshwater shark?

No shark species spends all its time in fresh water, but both the river shark and the bull shark have specially adapted kidneys that allow them to cope with fresh water for extended periods. They can swim hundreds of miles up large rivers in search of prey.

45 Where can I find sharks?

BASKING SHARK: temperate waters, both coastal and offshore
BULL SHARK: shallow tropical coastal waters, estuaries and large rivers
GREAT WHITE: coastal and offshore temperate waters worldwide
HAMMERHEAD: temperate and subtropical waters on the continental shelf
NURSE SHARK: shallow tropical reefs off the coast of West Africa and Central America
SHORTFIN MAKO: offshore tropical and temperate waters worldwide
TIGER SHARK: tropical and subtropical deep water around reefs
THRESHER SHARK: tropical and temperate waters on the continental shelf of North America and Asia
WHALE SHARK: offshore tropical and subtropical water, especially the west coast of Australia



INTERVIEW
Richard Peirce

Richard Peirce, chairman of the Shark Trust, answers a few questions about sharks, their behaviour around humans and how many species are becoming increasingly endangered.

46 What kinds of activities does the Shark Trust undertake?

The Shark Trust was founded in 1997 and it was set up to advance the profile of all families of sharks through awareness, education, legislation and policy. In recent years we have become accepted as the first stop for government departments wanting to take a look at fisheries legislation.

47 Which sharks are native to the UK's waters and are media claims of danger overblown?

My book, *Sharks In British Seas*, lists the 30 or so species that inhabit our native waters. There are many top-of-the-range and iconic species close to home. For example, the hammerhead is a British species; the same can be said for threshers, makos and blue sharks. A favourite of mine is also native: the porbeagle, which is a genuine mini great white… and is quite often mistaken as one.

On the area of danger to the public… there has never been a single recorded shark attack in British waters in the conventional sense. There have been shark-caused deaths and accidental incidents, but there has been nothing like we have tragically seen in the Seychelles recently, despite us having some sharks that certain people would consider dangerous to man.

48 Does a shark's behaviour differ in the presence of humans?

It differs mainly from species to species and between circumstances. If you are a diver on air and just chilling out, diving along a reef, that is completely different from being with a shark in a baited situation where its feeding senses have been stimulated. So if you are chumming for sharks – a process where you put an attractant into the water to generate a scent corridor – and in a cage then they will be behaving completely differently.

49 What is cage diving all about?

Cage diving is a fantastic way to see sharks… The cage has a hinged top that rests on the surface of the water. So the human jumps over the side of the boat and into the cage… They then proceed to move to the bottom of the cage, which is commonly about nine feet in depth. So the top of their head is usually only about three feet below the surface of the water… There is a rope out with some bait on it and the shark is drawn to that. The bait line is then drawn towards the cage and the shark will follow it. The boat's operator will then say something like 'coming in from the left', and the cage's occupant will then take a big draw of breath and submerge themselves for ten seconds or so, viewing the shark as it passes.

50 Where is the best place in the world to go cage diving?

I would say South Africa. It isn't necessarily the place with the clearest waters, but it is affordable and it is pretty commercialised, with companies running multiple dives a day. You can do it off Britain, though, and I myself helped set up Atlantic Divers in Newquay, Cornwall.

The ultimate hunting machine

Exploring great white shark hunting habits

One of nature's deadliest hunters in action

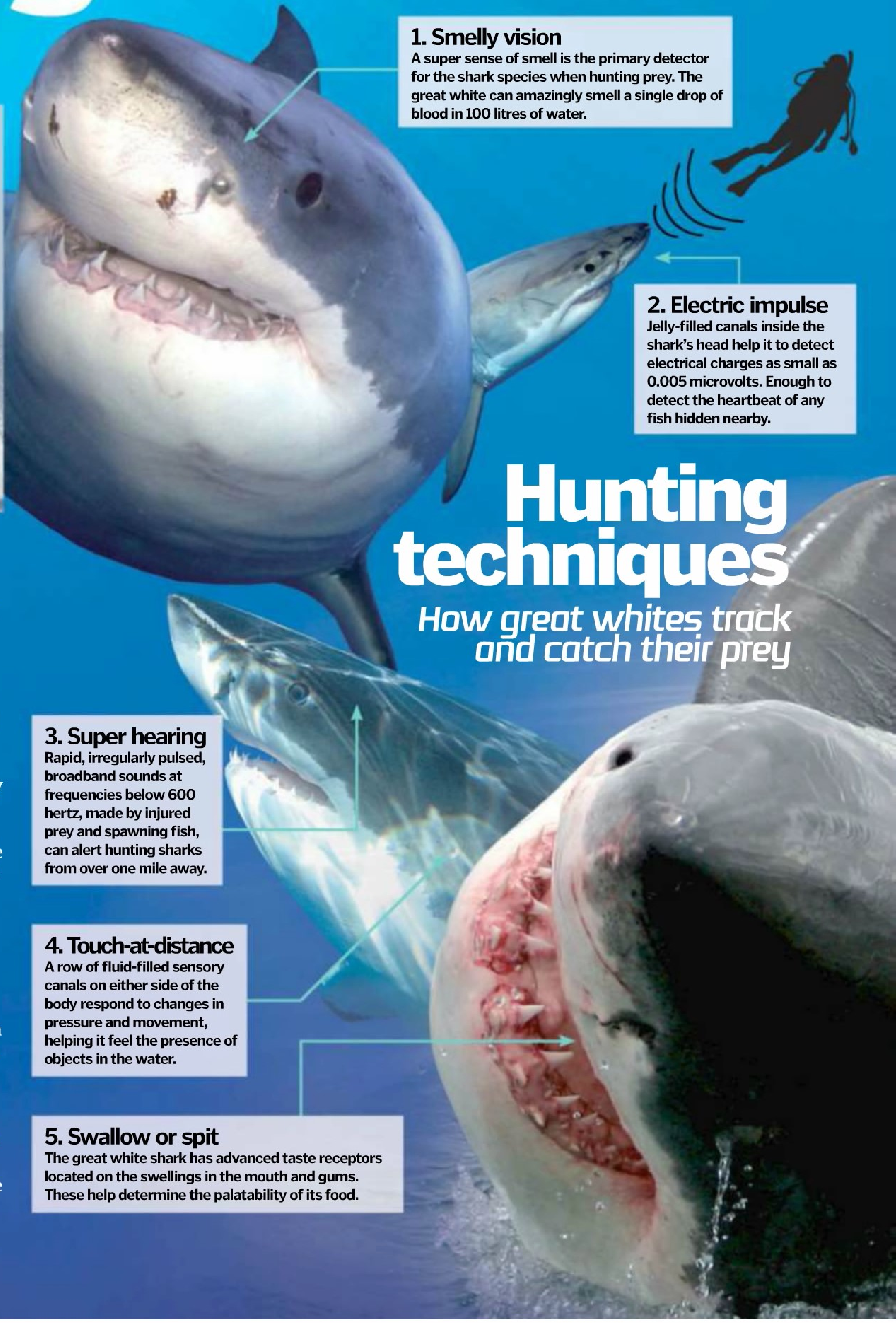
The great white shark, or Carcharodon carcharias, can only be described as the largest predatory fish in the sea. But is this aquatic marauder as fearsome as the popular media would have us believe?

It's certainly a species long in the tooth, in more ways than one. Firstly each of its incisors is a perfect cutting implement, triangularly serrated on both sides. These can grow up to as long as three inches. Upon maturity an adult great white can have anywhere up to 3,000 teeth jam-packed within its gaping jawline.

The way in which this and its teeth operate accordingly is truly remarkable. The great white shark has a floating jaw, enabling it to hold onto its prey with the lower part, as the upper jaw clamps down, tearing away flesh. Couple this with great white sizes reported up to as big as 20-feet or more, carrying weight of up to 2,240 kilograms, or 4,938lb, and that's one killer bite.

The great white's anatomy almost contradicts itself. With a torpedo-shaped torso, it propels itself with its powerful tail, reaching speeds up to 15 miles per hour. These sharks move much like aircrafts, less like conventional swimming fish species. Yet this momentum is used at an advantage, and the great white shark shows strategy in swiftly surprising prey from below. This usually consists of inflicting a fatal bite, which will sees its prey either die of shock or massive body trauma.

It's apparent that this species of shark has evolved into a remarkable hunting machine, quite literally the bloodhound of the sea. The great white has developed the most diverse array of sensors of any known predator.



Hunting techniques

How great whites track and catch their prey

1. Smelly vision
A super sense of smell is the primary detector for the shark species when hunting prey. The great white can amazingly smell a single drop of blood in 100 litres of water.

2. Electric impulse
Jelly-filled canals inside the shark's head help it to detect electrical charges as small as 0.005 microvolts. Enough to detect the heartbeat of any fish hidden nearby.

3. Super hearing
Rapid, irregularly pulsed, broadband sounds at frequencies below 600 hertz, made by injured prey and spawning fish, can alert hunting sharks from over one mile away.

4. Touch-at-distance
A row of fluid-filled sensory canals on either side of the body respond to changes in pressure and movement, helping it feel the presence of objects in the water.

5. Swallow or spit
The great white shark has advanced taste receptors located on the swellings in the mouth and gums. These help determine the palatability of its food.

5 TOP FACTS SWIM BLADDERS

Tasty

1 In certain Asian cultures the swim bladders of large ocean fish are considered a tasty foodstuff, renowned as a delicacy that is commonly served braised.

Origin

2 Charles Darwin wrote: "There is no reason to doubt the swim bladder has been converted into lungs [and that] all vertebrates with true lungs are descended from an ancient prototype."

Hearing

3 In some fish the swim bladder is connected to the labyrinth of the inner ear by a bony structure from the vertebrae. This provides a precise sense of water pressure and hearing.

Gas

4 The mix of gases in swim bladders varies. Shallow-water fish bladders tend to approximate that of Earth's atmosphere, while deep-sea fish have higher oxygen mixes.

Bladder-free

5 Cartilaginous fish like sharks lack both lungs and swim bladders. This has led to postulation that both these organs developed 420 million years ago after such species divided from other fish.

DID YOU KNOW? [illegible] [6.6 feet] wide

Why do some animals play dead?

Learn about the critters that feign death in order to live another day

Perhaps one of the most peculiar behaviours witnessed in the animal kingdom, tonic immobility is an involuntary reflex where a creature experiences total paralysis and, essentially, appears dead. Often demonstrated by sharks and some bony fish when turned on their backs, the animal enters a cataleptic state – much like the proverbial 'rabbit caught in the headlights'. Whether it's your world being flipped 180 degrees or a car hurtling towards you, it's believed this condition is the result of some form of sensory overload. Left to their own devices, most fish will 'come to' within 15 minutes and return to normal, however certain chemicals can be used to speed up the process.

Although an animal might look dead when in a tonic state, there's a distinction to be made between tonic immobility – which is outside a creature's control – and thanatosis, which is an instinctual behaviour where death is actively feigned. This is seen across mammals (eg opossum – hence 'playing possum') to reptiles (eg grass snake) and insects (eg pselaphid beetle). Most use the technique as a defence to deceive predators, or members of their own species, into thinking they're already dead, but a few actually use it as a means of predation. For example, the pselaphid beetle tricks ants into carrying it back to their nest, where it will dine on the colony's eggs and larvae.

There has been some research into whether humans can experience tonic immobility and recent studies suggest we can in extremely traumatic situations, where we essentially 'switch off' from a life-threatening situation. Most likely our brains trigger this response to try and reduce psychological damage.

Flipping a shark may not be the easiest defensive manoeuvre to pull off...

Scx.hu

How can a fish remain buoyant?

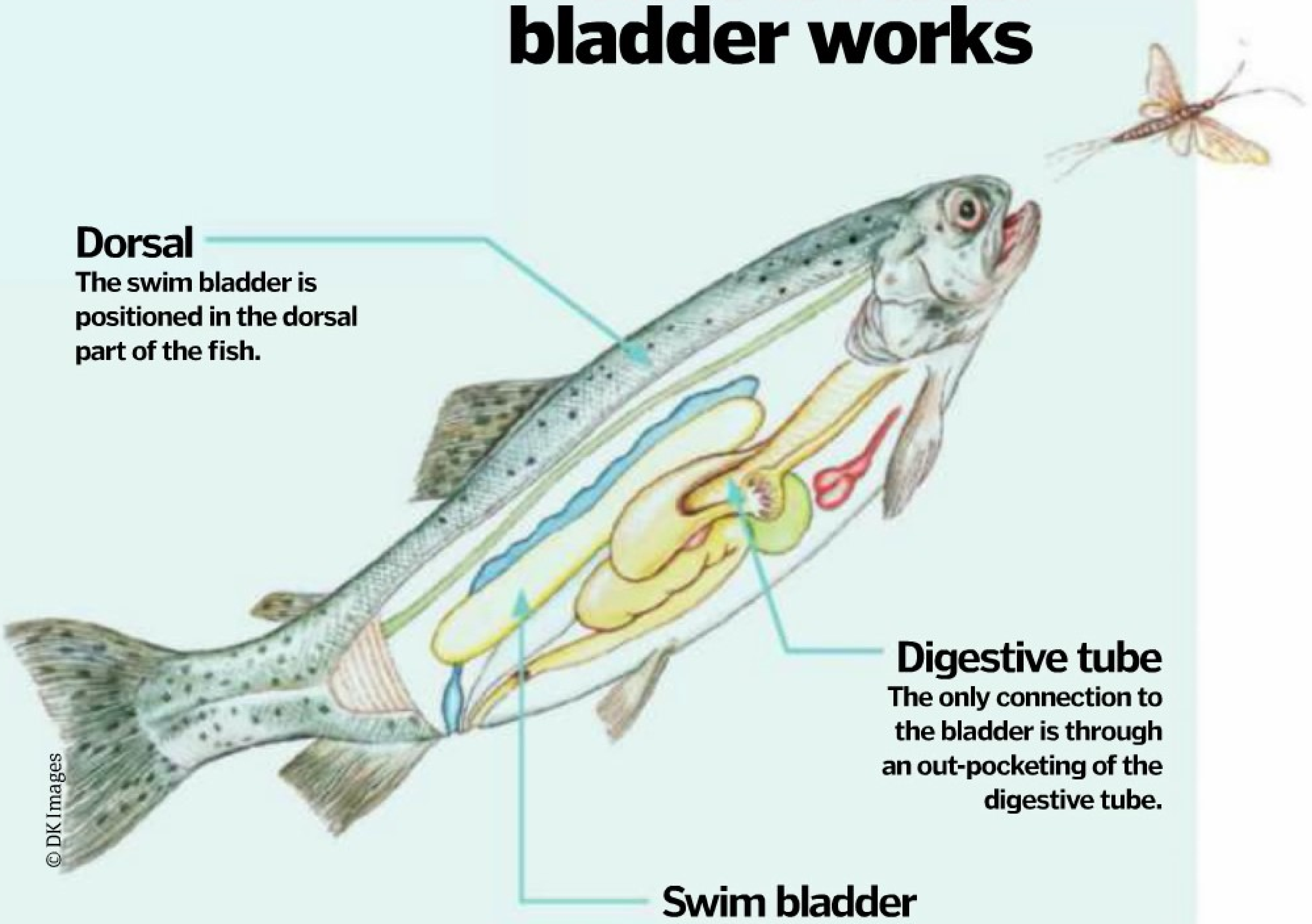
Learn how the swim bladder organ gives fish an internal ballast system

Swim bladders are buoyancy-aiding organs possessed by the majority of bony fish. The organ is located in the fish's body cavity and originates from an out-pocketing of the digestive tube. It is filled with a variety of gases including oxygen, carbon dioxide, argon and nitrogen and functions as a biological ballast system, allowing the fish to efficiently maintain its depth.

Swim bladder structure usually consists of two sacs located in the dorsal portion of the fish that, due to flexible walls, can expand or contract according to ambient pressure (ie depth). These flexible walls are commonly lined with guanine crystals in order to make them impenetrable to auxiliary gases and, as a consequence, are predominantly closed structures.

Gas to expand the swim bladder is produced by a dedicated gas gland. This works by excreting lactic acid to produce carbon dioxide. The resultant acidity then causes the haemoglobin in the fish's blood to shed its oxygen – a process that is known as the 'Root effect' – and diffuse partly into the bladder.

How a swim bladder works



Dorsal
The swim bladder is positioned in the dorsal part of the fish.

Digestive tube
The only connection to the bladder is through an out-pocketing of the digestive tube.

Swim bladder
The bladder consists of two sacs filled with various gases.

© DK Images

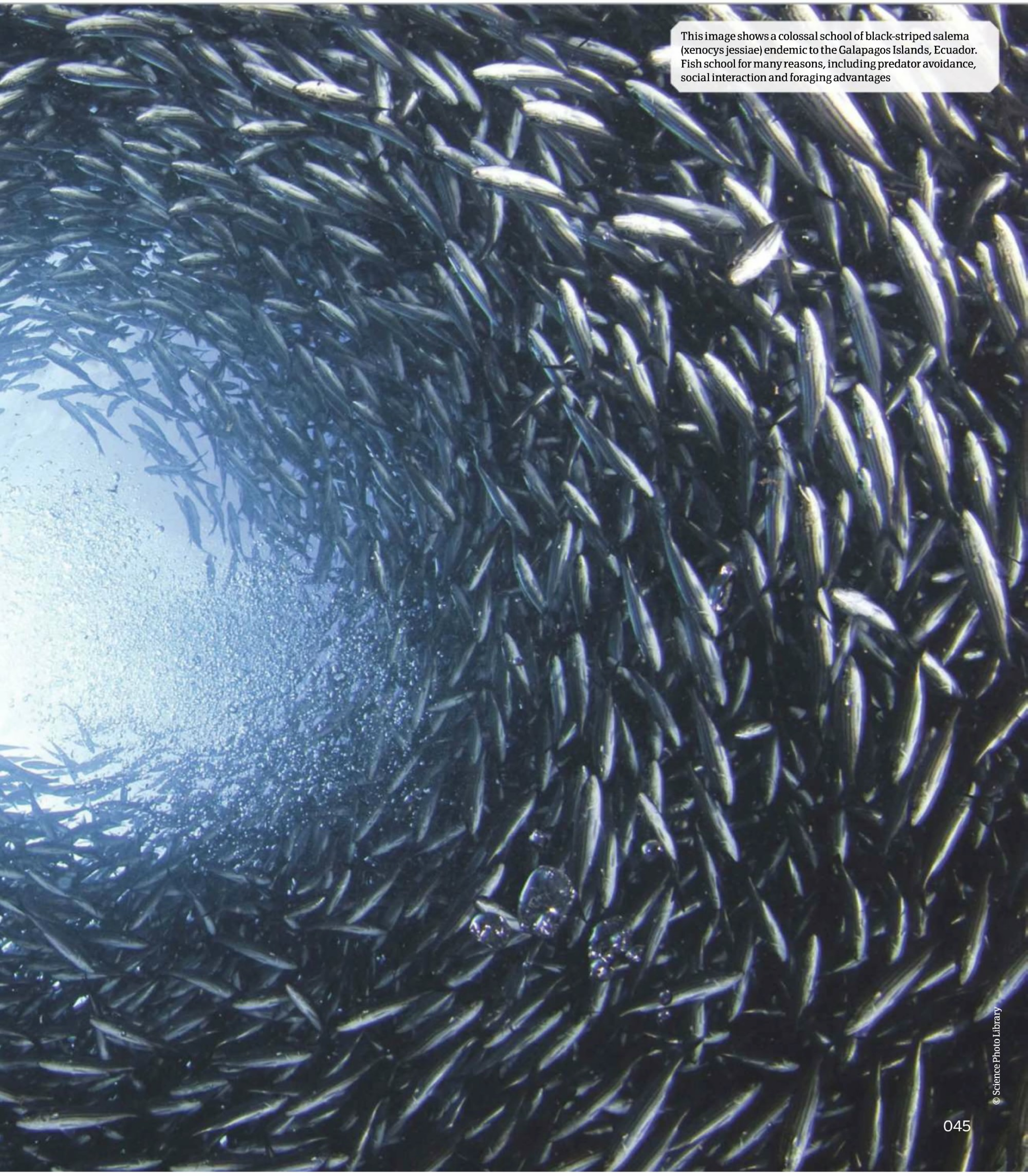
Schooling fish

How and why do large numbers of fish group together in massive shoals?

Of all the species of fish in the world, one quarter of them shoal and/or school for their entire lives, while about one half participate in the action for limited periods of time. Together this means that vast selections of fish school at some point or another, coming together to swim in synchronicity.

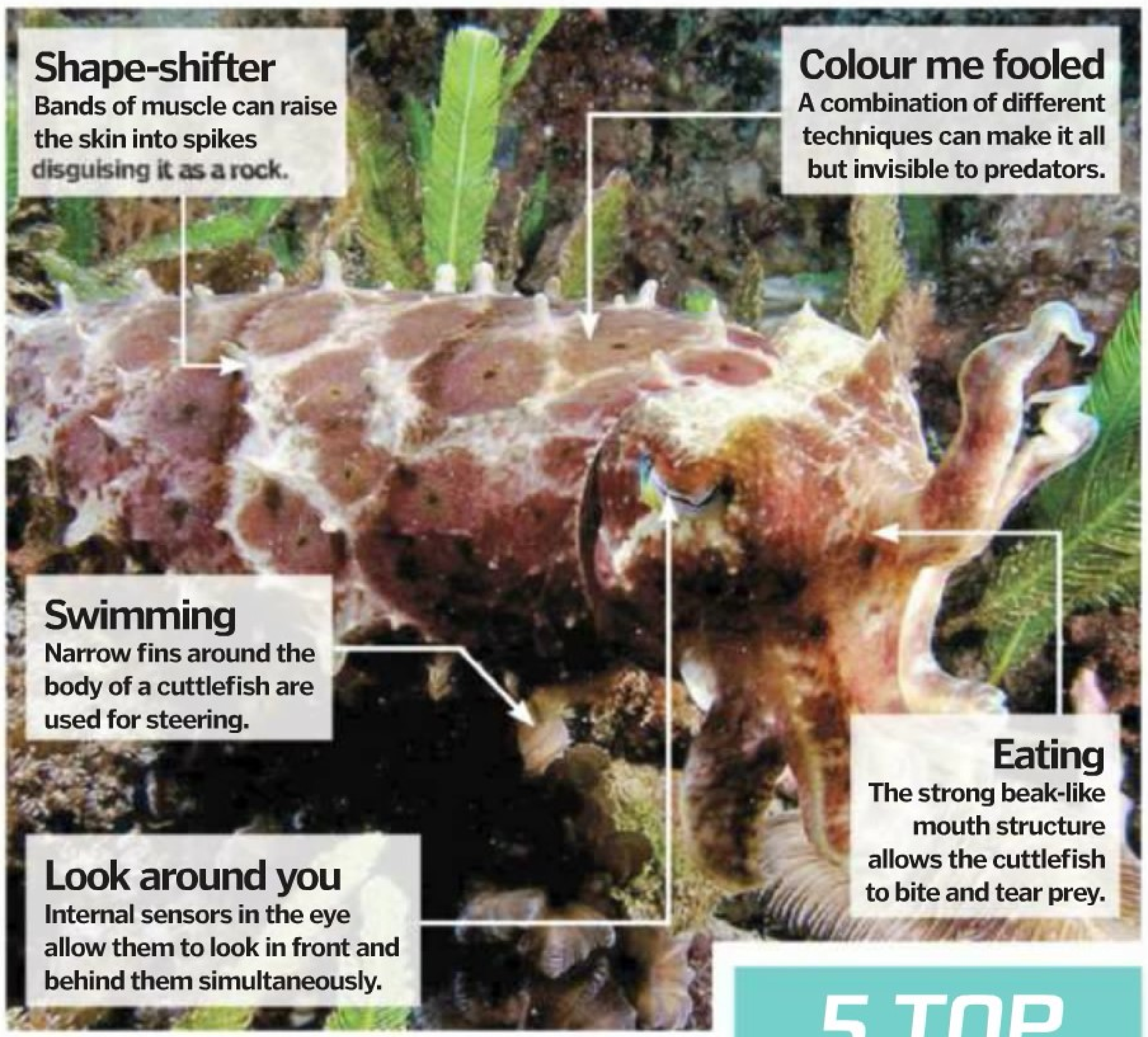
Fish perform this phenomenon for a number of reasons. The first is to support social and genetic functions, aggregating together to increase the ease of communication and reduce stress – experiments have shown that heart rate reduces significantly in shoaled fish compared to those alone. The second advantage of schooling is to boost the group's foraging success, which has been proven in trials to grow considerably in comparison to a solitary specimen. This is simply because the number of eyes looking for food increases dramatically and, partnered with the ability for each fish to monitor the behaviour of those around it, means that when one fish demonstrates feeding behaviour, the others follow.

Finally, the third – and primary – reason why fish school is for protection. By grouping into a tight, regimented pattern, the fish minimise their chance of being picked off by generating a sensory overload to a predator's visual channel. The swirling mass of twisting silvery fish creates a blending effect where the predator struggles to track a single target and becomes confused.



This image shows a colossal school of black-striped salema (xenocys jessiae) endemic to the Galapagos Islands, Ecuador. Fish school for many reasons, including predator avoidance, social interaction and foraging advantages

© Science Photo Library



Shape-shifter
Bands of muscle can raise the skin into spikes disguising it as a rock.

Colour me fooled
A combination of different techniques can make it all but invisible to predators.

Swimming
Narrow fins around the body of a cuttlefish are used for steering.

Eating
The strong beak-like mouth structure allows the cuttlefish to bite and tear prey.

Look around you
Internal sensors in the eye allow them to look in front and behind them simultaneously.

Cuttlefish camouflage

How do these masters of disguise avoid being found?

Part of the cephalod family, the cuttlefish is a remarkable mollusc that can change its colour to protect itself against predators. Cuttlefish have a combination of cells stacked in different layers in their skin that operate in unison to produce a swift and impressive camouflage technique.

The most important of these cells are the chromatophores, which hold pigments of different colour directly under the skin. They are attached to a group of 15-25 muscles, and when the muscles contract or relax they can make a specific pigment larger or smaller, thus altering the surface colouration of the skin.

Another layer of cells, the leucophores, help the cuttlefish blend into the environment around them. These flattened and branched cells can scatter and reflect the incoming light on the cuttlefish, therefore giving the skin the same colouration as the main wavelength of light in the environment.

5 TOP FACTS

OTHER CUTTLEFISH PARTY TRICKS

1 Cuttlefish can add a pair of eye spots to the back of their body, fooling predators into thinking they are being watched.

2 Cuttlefish have three separate hearts. One controls the pumping of the blood around the body, and the other two each serve a separate gill. Doctor Who has a measly two.

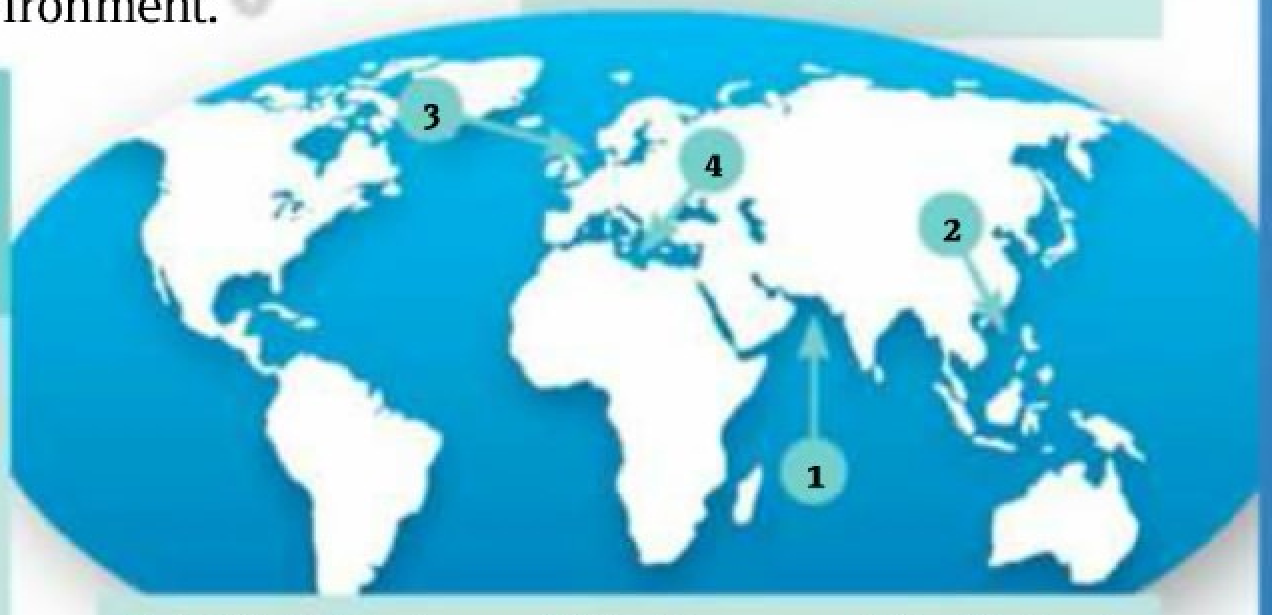
3 Amazingly, the cuttlefish can adopt male and female colouration on separate sides of its body. This allows one to trick a male and female pair who may be guarding eggs.

4 They can also spray ink to confuse predators and make their escape. The ink is ejected as a cloud, allowing the cuttlefish to get away.

5 If you thought these molluscs couldn't get any more incredible, think again. Using their camouflage techniques to alter the appearance of their body, they can stun their prey before striking.

ON THE MAP

Cuttlefish need to be able to hunt their usual prey of shrimp in calm waters in order to avoid detection. Therefore they usually reside in shallow and sandy coastal waters.



1 Indian Ocean
2 Western Pacific
3 The European Atlantic Coast
4 Mediterranean

How do lionfish survive?

A fish of many names, but there's no mistaking that it's a born survivor

With its graceful fins and zebra-like stripes, the lionfish may not look particularly feline, but compared to some of its other nicknames – like the dragonfish and, believe it or not, even the turkeyfish – it doesn't seem so far-fetched. Perhaps the most appropriate moniker that this sea creature goes by is scorpionfish (the wider family to which this species belongs), because it can deliver a very nasty sting.

However, the series of needle-like spines (up to 18), which line its upper body and can each inject a dose of powerful venom, are not used to kill. This weapon is purely a defensive one deployed when the lionfish feels threatened. Although being stung by these spines is very painful for humans – potentially leading to sickness or breathing problems – fatalities are extremely rare. That's not to say the lionfish isn't an adept killer of other marine life. It is very much an ambush predator where any prey – mainly consisting of fry and small crustaceans like prawns – that ventures too close falls victim to this species' lightning-fast reflexes; once in range, prey are simply gulped whole.

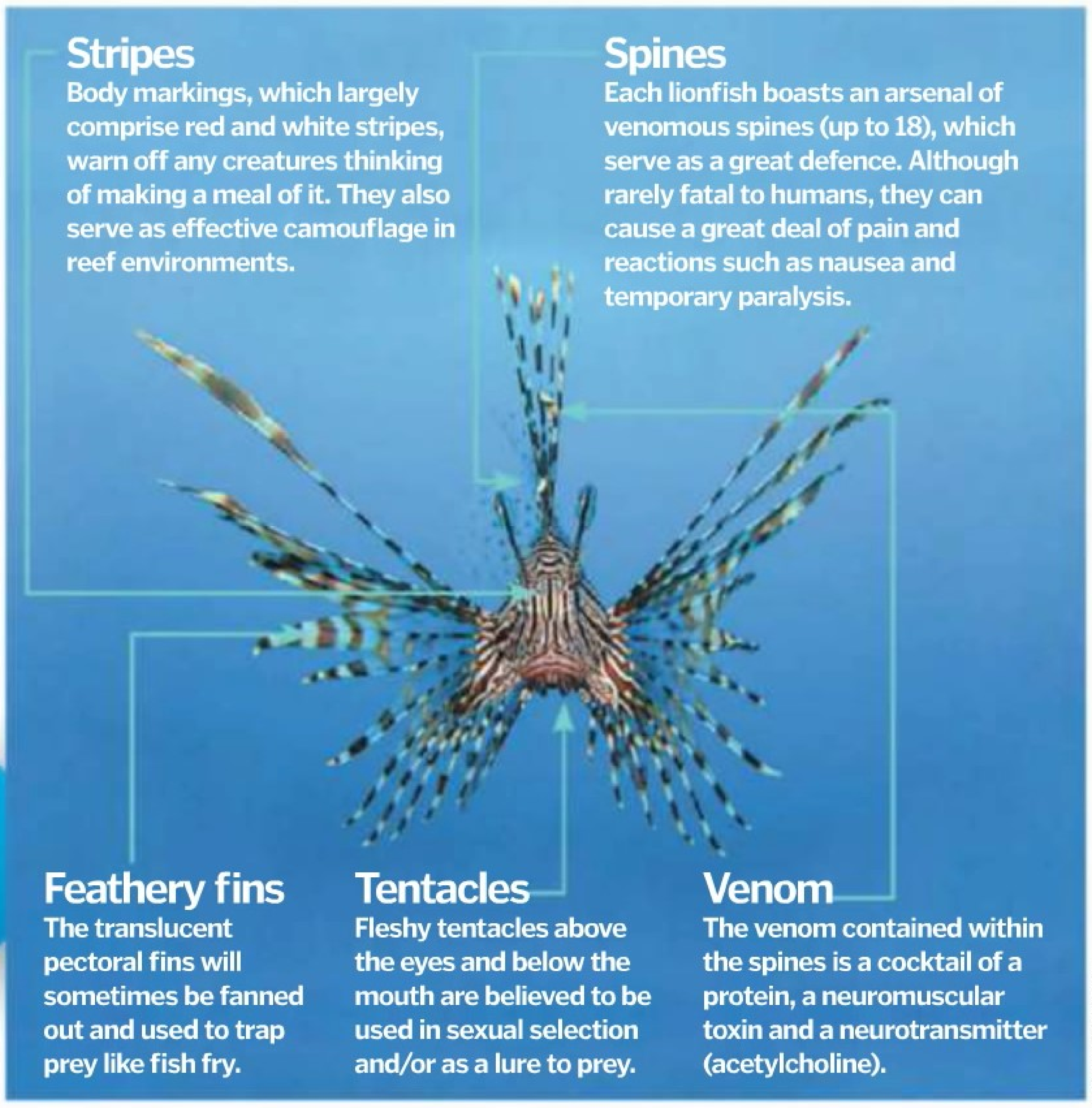
Originating from the Indo-Pacific region, since the Nineties lionfish populations have seen a boom in other tropical seas like the Caribbean and the Gulf of Mexico. This is likely a result of pet owners releasing fish that have grown too big for their tanks into the sea. It's a major concern to conservation groups, as not only does this invasive species have few predators, it also has a very high reproduction rate. Females can spawn up to 30,000 eggs in one week alone (that equates to roughly 1.5 million eggs a year).

The statistics…

© OpenCage

Lionfish

Genus: Pterois
Length: 30-38cm (11.8-15in)
Weight: Up to 1.2kg (2.6lb)
Diet: Carnivore (eg fish, shrimp)
Life span in wild: Up to 15 years



Stripes
Body markings, which largely comprise red and white stripes, warn off any creatures thinking of making a meal of it. They also serve as effective camouflage in reef environments.

Spines
Each lionfish boasts an arsenal of venomous spines (up to 18), which serve as a great defence. Although rarely fatal to humans, they can cause a great deal of pain and reactions such as nausea and temporary paralysis.

Feathery fins
The translucent pectoral fins will sometimes be fanned out and used to trap prey like fish fry.

Tentacles
Fleshy tentacles above the eyes and below the mouth are believed to be used in sexual selection and/or as a lure to prey.

Venom
The venom contained within the spines is a cocktail of a protein, a neuromuscular toxin and a neurotransmitter (acetylcholine).

© Jens Peterson

The deadly pufferfish

A look at why, despite its size and timid appearance, one type of fish can be extremely deadly when it comes to defending itself

The pufferfish is a group of over 100 species that are so-named for their unique line in defence. When cornered, a puffer's last gasp is to draw in water (or sometimes air) and pump it to the stomach, expanding to three times its normal size; deterring potential predators and when possible, affording it the vital seconds necessary to escape.

To achieve this with the required efficiency and speed, once the puffer has taken on water its gills clamp shut and a powerful bow-door-like valve closes over the inside of the mouth. Once the mouth's cavity is compressed, this forces the water into its stomach.

Despite its resulting comic appearance, the tissues and organs of many a puffer are no joke, laced with the potent poison tetrodotoxin – a single pinhead of which could kill a grown man. This makes it ten times more deadly than the black widow spider. The poison is produced as part of a mutually beneficial relationship by common bacteria where nutrients are exchanged as payment for the ultimate deterrent.

Some species such as the porcupine puffer are more sporting than others, covered with spines that offer added protection and ample warning to any would-be attackers. Each spine is attached to the skin by an ingenious tripod-shaped bony base. When the skin stretches, one of the legs is pushed forward and two are pulled back to snap the spine outwards… a point well made in more ways than one.

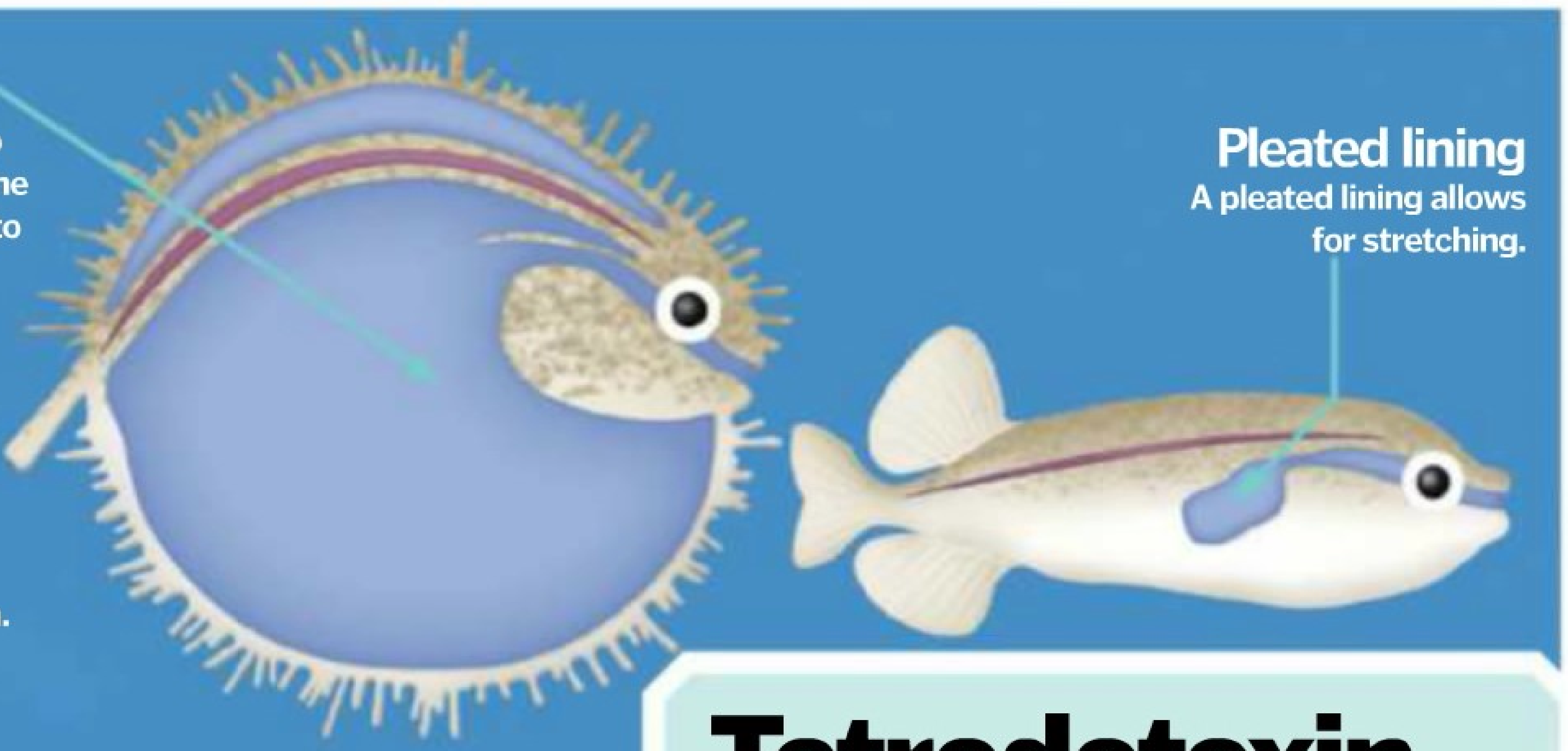
Fact File

Pufferfish

Type: Fish
Diet: Omnivore: algae, molluscs, invertebrates and crustaceans
Average life span: 4-8 years
Power: Pressurised water reactor, fuelled for life
Weight: 150g-30lbs
Size: 1in-3ft
Habitat: Tropical/sub-tropical, saltwater, brackish, freshwater

How it blows

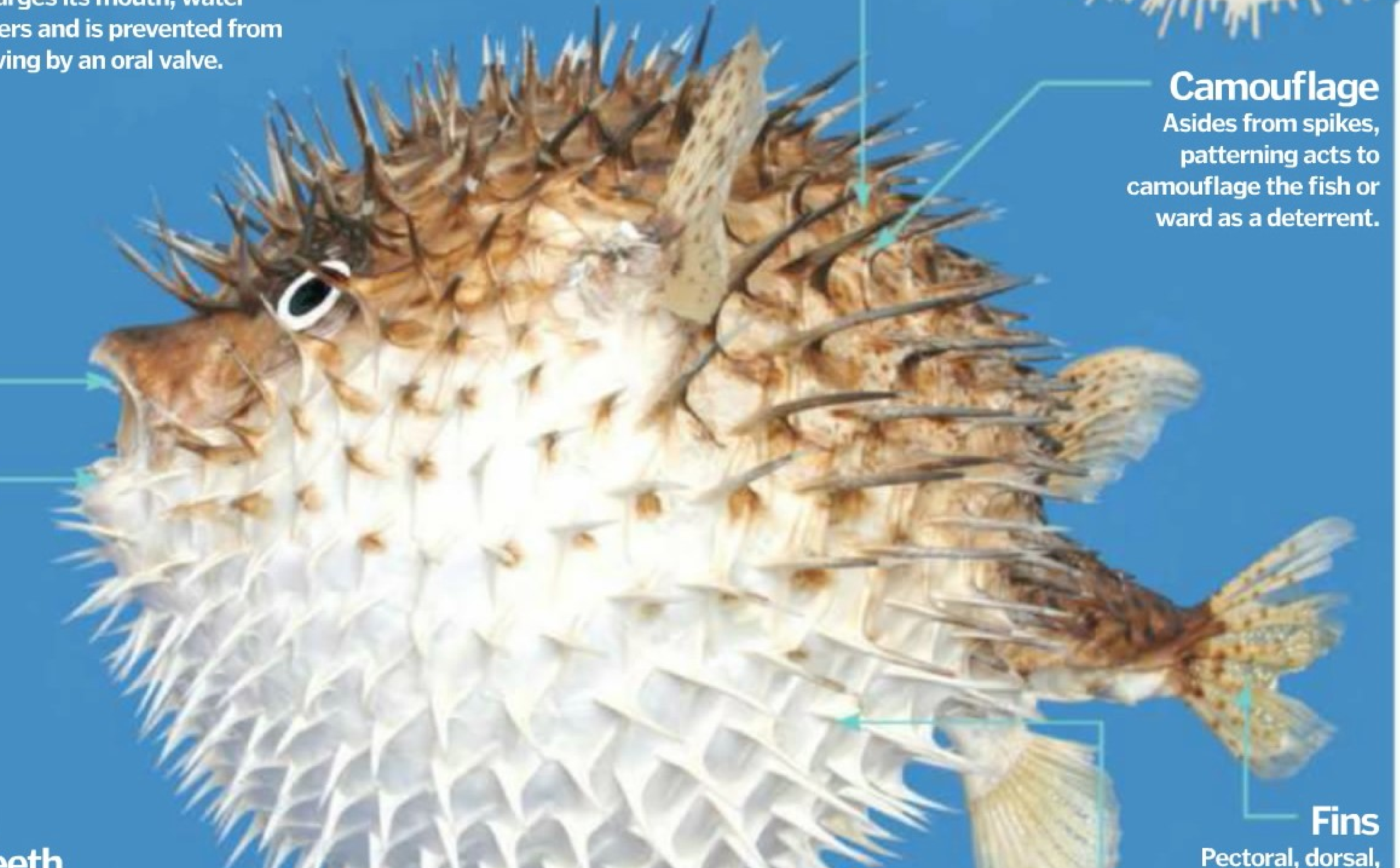
As water enters the stomach, kilted pleats in the inner-lining allow it to flex and stretch under enormous pressure. As the stomach cavity fills, it balloons above and around the spine, continually pulling the inner-lining fibres so tight that they harden to form an almost perfect impenetrable sphere.



Stomach
Water flows from the mouth to the stomach by compressing the oral cavity. Its stomach bloats to 100 times its initial volume.

Pleated lining
A pleated lining allows for stretching.

Organs
Despite its arching spine and absence of ribs, the internal organs are squeezed between the backbone and the stomach.



Mouth
To expand, the pufferfish enlarges its mouth; water enters and is prevented from leaving by an oral valve.

Camouflage
Asides from spikes, patterning acts to camouflage the fish or ward as a deterrent.

Teeth
Pufferfish have four large teeth fused into an upper and lower plate.

Fins
Pectoral, dorsal, caudal and anal fins optimise movement.

Skin
It is pleats that allow this fibrous inner-layer to expand and are responsible when stretched for its rigid form.

Outer skin
This elastic layer provides a smooth hydrodynamic profile as cover to the inner pleated layer.

Spikes
Some species sport modified scales that lay flush to the skin. A tripod-shaped base causes them to snap up when the fish is puffed.

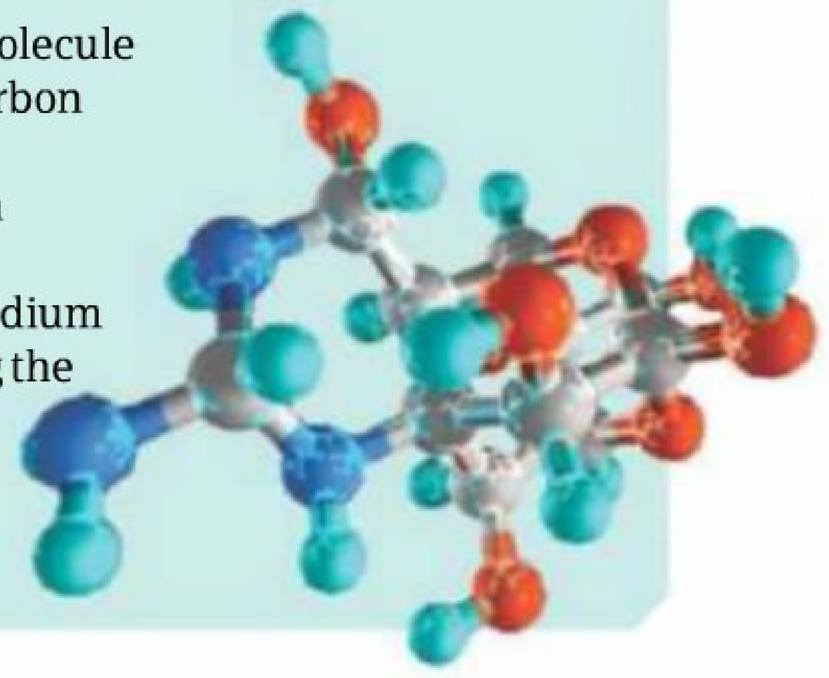
TTX
The most potent repellent lies in high concentrations of TTX found in the skin, gonads, liver and intestines.

Tetrodotoxin

Second only to the golden dart frog, pufferfish are said to rank as the most deadly vertebrate on Earth. The poison it carries, tetrodotoxin (TTX), is not of its own making; it is produced, in association, by relatively common marine bacteria and dinoflagellates.

In susceptible animals, TTX binds to the sodium channels of nerve cells, halting the influx of sodium and causing a cessation of nerve function; this leads to suffocation, paralysing the diaphragm and causing the death of its victim. There is no known cure.

Humans are most likely to taste its deadly effect from improperly prepared Japanese delicacy, fugu. The diner can expect a deadening of the mouth, dizziness, vomiting and difficulty breathing. This is followed by respiratory failure and coma or death within 24 hours if treatment is not forthcoming.



Each atom of the molecule is colour-coded: carbon (grey), hydrogen (turquoise), oxygen (red) and nitrogen (blue). It binds to sodium channels, blocking the transmission of nerve impulses and poisoning the nervous system.

©Science Photo Library

How do anglerfish hunt?

Discover how these menacing fish use bioluminescence to search for prey

Anglerfish are usually found in deep and temperate tropical seas, around 1,000m (3,300ft) below sea level. Protruding from their head is a long and thin growth made of flesh, used like the lure of a fishing rod to attract prey. Some species have luminescent bacteria in the tip to more easily search for and attract prey in the darkness of the deep ocean.

The light produced is blue-green in colour, as most marine animals are sensitive to blue light, and it also travels best in water. The tip of an anglerfish's growth, the photophore, contains the light-producing chemicals that cause bioluminescence. A compound known as 'luciferin' is oxidised by an enzyme known as 'luciferase', which produces the cold light and attracts prey.

> "An anglerfish's photophore contains the chemicals that cause bioluminescence"

The most venomous fish in the world

Almost invisible among the coral reefs, the stonefish is a real-life killer

The stonefish is the world's most venomous fish thanks to its ability to inject deadly neurotoxins from the spines on its dorsal fin into its target. The stonefish's neurotoxins work by attacking the nerve cells of whatever it is injected into, causing severe pain, sickness, nausea, paralysis and, depending on the depth of spine penetration into skin, death within three hours (humans can be killed just two hours after being poisoned).

Unlike most other poisonous fish who dwell in the dark depths of the ocean - leaving little chance of human contact – stonefish dwell in shallow waters and are likely to be found anywhere between just a beneath the surface down to a depth of three metres.

> "The stonefish's neurotoxins work by attacking nerve cells"

If it doesn't want to be stepped on, why evolve to look like a stone!

© R Wampers 2004

The archerfish explained

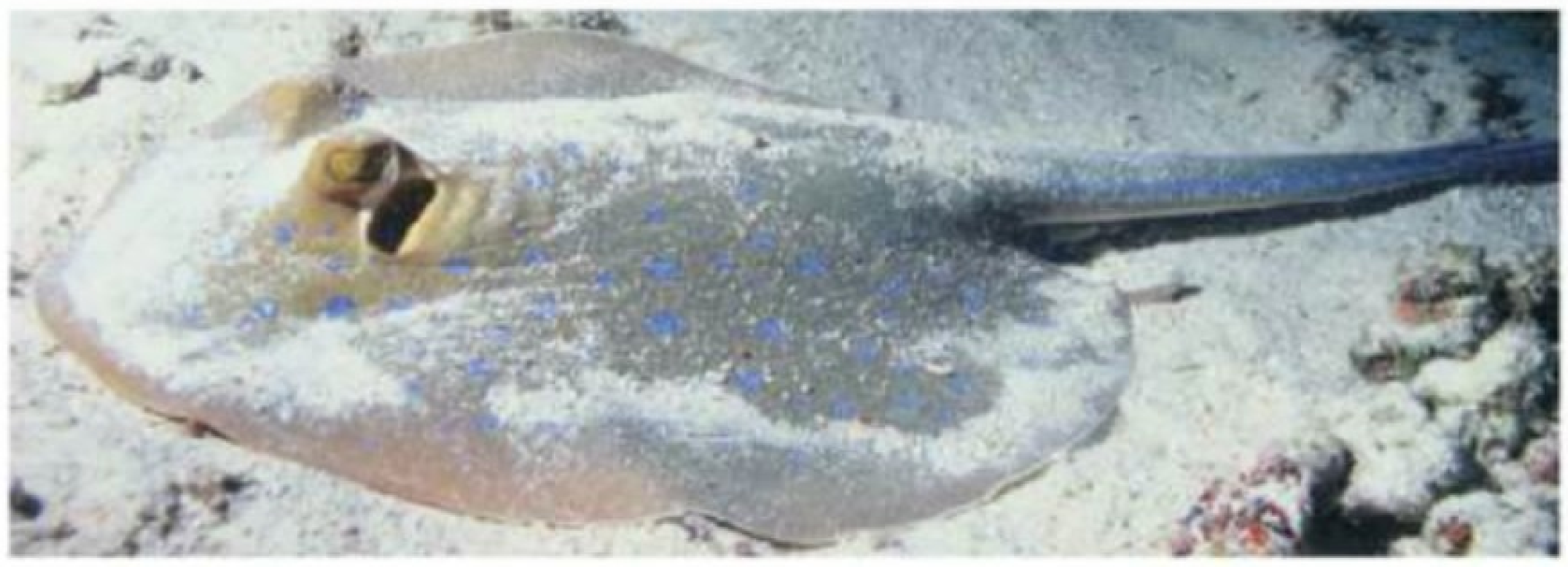
The fish that thinks it's a water pistol

Found in the mangroves and brackish waters of southeast Asia and northern Australia, the archerfish is known for its ability to capture aphids and other tiny insects from branches overhanging the water's edge with a highly accurate jet of water from its mouth.

First the archerfish sneaks up on its land-based prey, aided by its thin body and black-and-white vertical striped skin that blends with the mottled swamp light. Next it takes aim at the insect, and presses its tongue against a groove in the roof of its mouth to create a channel through which a fast jet of water can escape. By rapidly closing its gills, the fish produces this accurate stream of water that reaches 1.5m (5ft) to knock the insect into the water to be eaten. The archerfish uses the tip of its tongue to aim the jet, and for added accuracy it can boast a pair of large, binocular eyes located near its mouth. To allow for the fact that the location of the prey is distorted by refraction (light from the prey travels first through the air and then through the denser water), the archerfish has also learned to adjust its aim accordingly, targeting just below the victim.

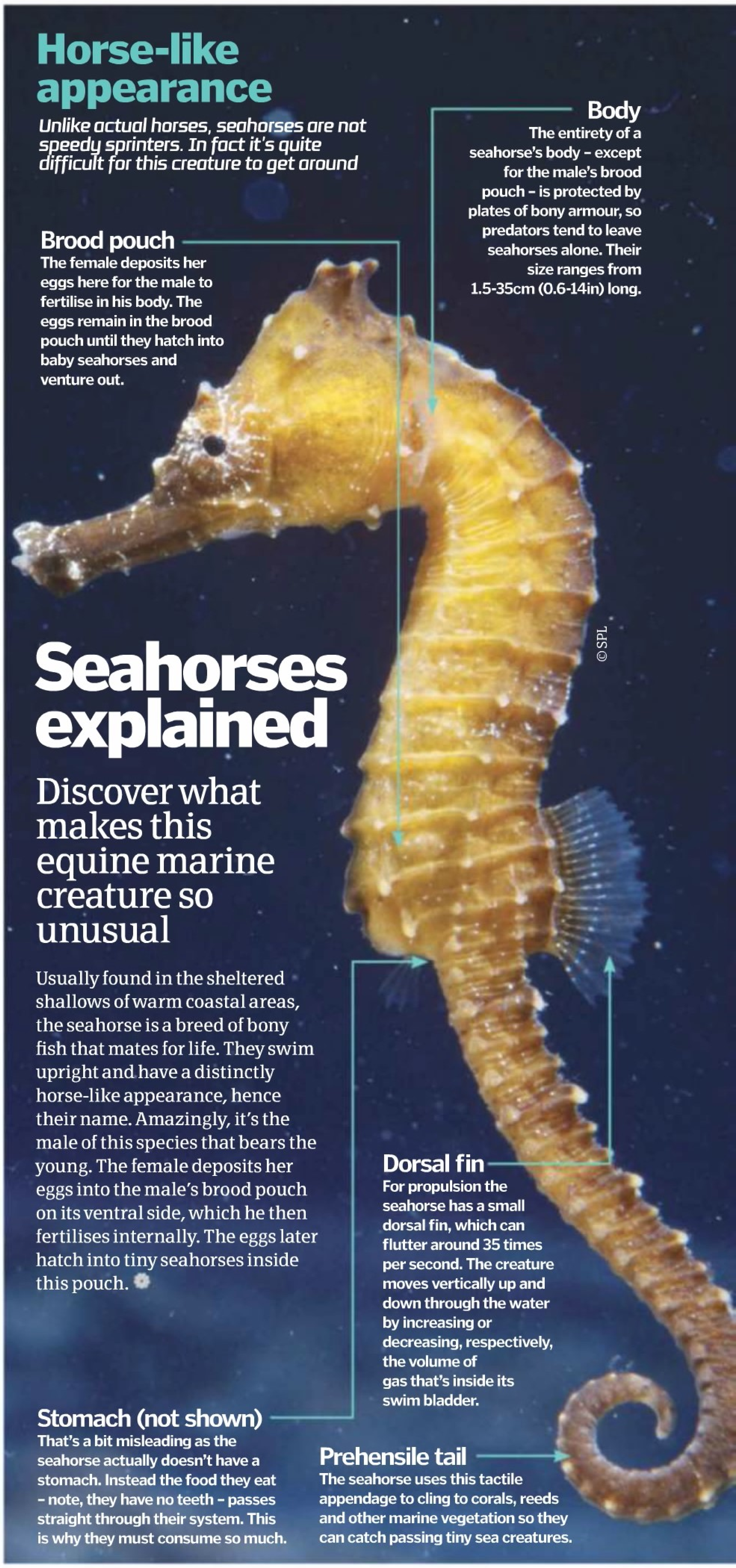
Stingrays explained

How do these spiny, flat-bodied fish which dwell on the seabed live?



Stingrays are flat-bodied rays who inhabit the majority of Earth's oceans, from the North Atlantic to the South Pacific, and are also bottom-dwellers who mostly operate close to the seabed. In fact they regularly camouflage themselves from predators by lying dormant on the seabed partially covered in sand and silt. This can make them particularly difficult to spot, especially for humans, and due to some species sporting spiny venomous tails, they can prove dangerous if accidentally provoked. Their diet mainly consists of sea worms and other small invertebrates, which they consume with their bottom-mounted mouth.

Most stingrays sport one or more barbed stings on their tail, which are modified forms of dermal denticles. The stinger itself can grow to over 35 centimetres (13.8 inches) and is envenomed by glands positioned on its underside. The venom is concentrated over the stinger in a thin layer of skin.


© SPL

Seahorses explained

Discover what makes this equine marine creature so unusual

Usually found in the sheltered shallows of warm coastal areas, the seahorse is a breed of bony fish that mates for life. They swim upright and have a distinctly horse-like appearance, hence their name. Amazingly, it's the male of this species that bears the young. The female deposits her eggs into the male's brood pouch on its ventral side, which he then fertilises internally. The eggs later hatch into tiny seahorses inside this pouch.

Horse-like appearance

Unlike actual horses, seahorses are not speedy sprinters. In fact it's quite difficult for this creature to get around

Body
The entirety of a seahorse's body – except for the male's brood pouch – is protected by plates of bony armour, so predators tend to leave seahorses alone. Their size ranges from 1.5-35cm (0.6-14in) long.

Brood pouch
The female deposits her eggs here for the male to fertilise in his body. The eggs remain in the brood pouch until they hatch into baby seahorses and venture out.

Dorsal fin
For propulsion the seahorse has a small dorsal fin, which can flutter around 35 times per second. The creature moves vertically up and down through the water by increasing or decreasing, respectively, the volume of gas that's inside its swim bladder.

Stomach (not shown)
That's a bit misleading as the seahorse actually doesn't have a stomach. Instead the food they eat – note, they have no teeth – passes straight through their system. This is why they must consume so much.

Prehensile tail
The seahorse uses this tactile appendage to cling to corals, reeds and other marine vegetation so they can catch passing tiny sea creatures.

Octopuses

The incredible abilities of this eight-legged wonder of the natural world, exposed

Octopuses are the superheroes of the animal kingdom, with so many amazing abilities and adaptations that it begins to look greedy. They can solve mazes, open screw-top jars and use tools. They can walk, they can swim and they can even jet propel themselves at high speed. They can change colour, imitate other animals, squirt ink, inject poison and jettison their own legs. When you can do all that, who cares if you can predict football results or not?

Although they are molluscs, octopuses don't have a shell or bones and the only hard part of their body is a small beak, made of keratin. This allows them to squeeze through extremely small gaps – an octopus a metre across can pass through a tube the size of a 50 pence coin. Octopuses mainly eat crabs and small fish that they winkle out of crevices in rocks and coral reefs, but they can also tackle small sharks by enveloping the shark's gill openings and suffocating them.

Octopus blood uses a greenish-blue copper pigment called haemocyanin, instead of the iron-based haemoglobin in our own blood. Haemocyanin can't carry as much oxygen as haemoglobin, but it is actually more efficient at low oxygen concentrations and in cold water. Despite this, octopuses have poor circulation and quickly run out of energy. This may be one of the reasons for their intelligence – they don't have the stamina for a prolonged chase and must rely on their cunning.

Male octopuses die almost immediately after mating. The females are even bigger martyrs. They guard their 20,000 eggs for a month and rather than leave the nest to hunt, they will eat some of their own legs. After that, the female dies and the eggs hatch into babies approximately the size of a walnut.

The statistics...

© H.Zell

Octopus

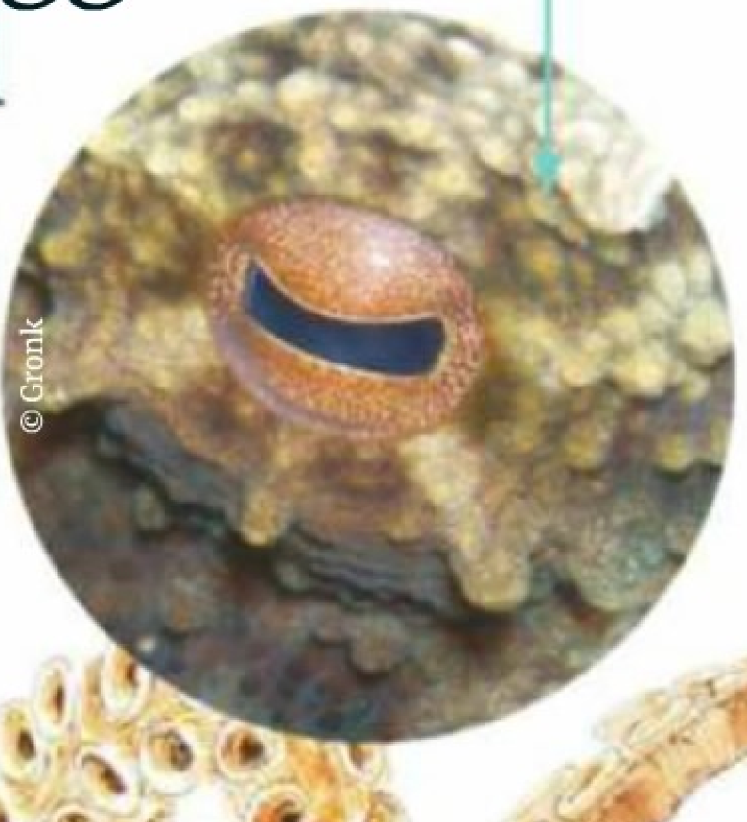
Class: Cephalopod

Diet: Carnivore

Average life span in the wild: 6 months–5 years

Weight: 0.1-200kg

Size: 3cm–9m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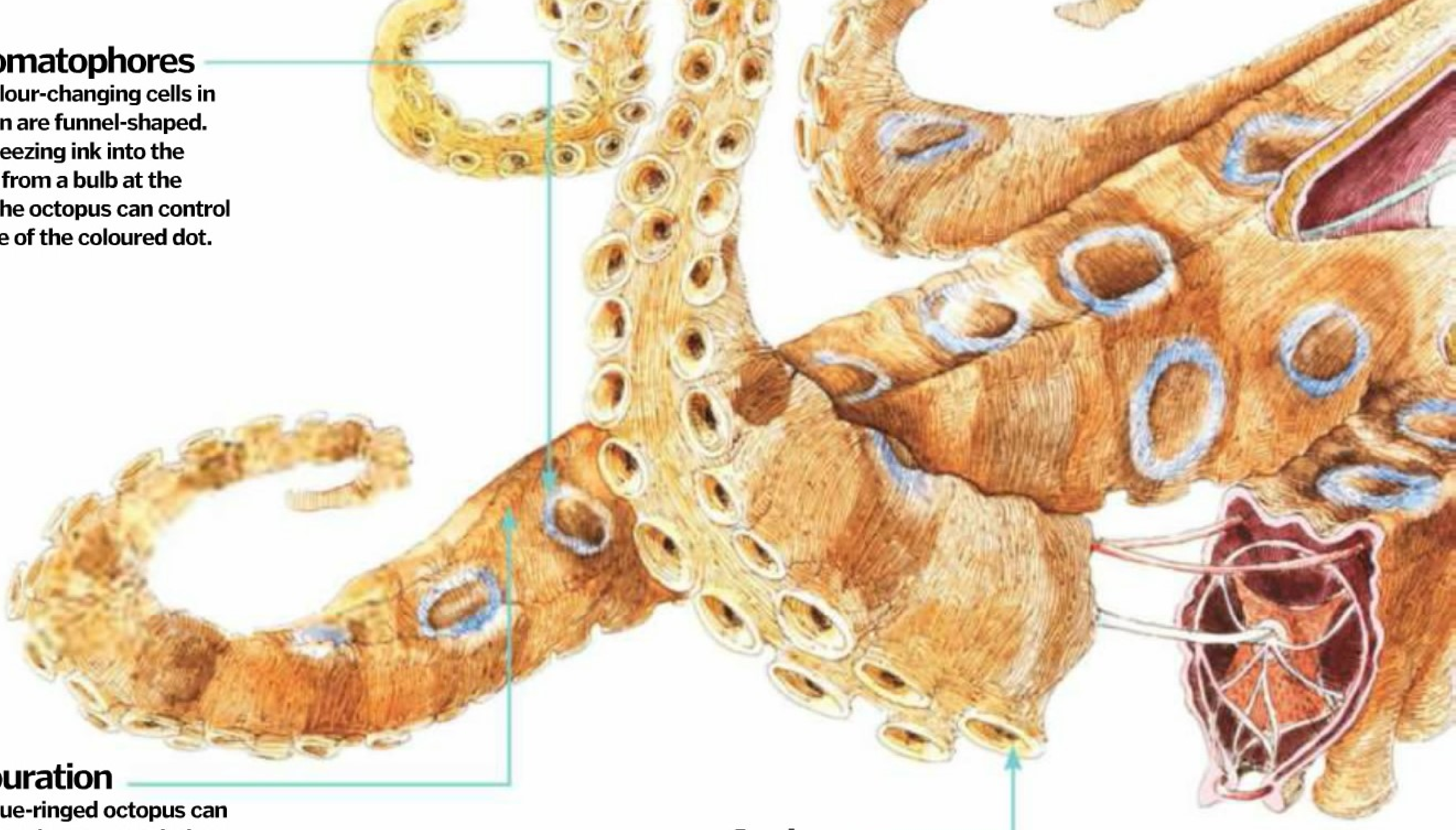


Eye
This looks much like our own, with a lens and an iris but it evolved in a different way. Octopuses don't have a blind spot where the optic nerve passes through, because the retina is positioned differently.

Poison glands
These evolved from salivary glands, and as well as paralysing prey they also soften up the flesh, making it easier to eat.

Chromatophores
The colour-changing cells in the skin are funnel-shaped. By squeezing ink into the funnel from a bulb at the base, the octopus can control the size of the coloured dot.

Colouration
This blue-ringed octopus can change colour to match the sea bed or suddenly flash the bright blue rings to startle predators.

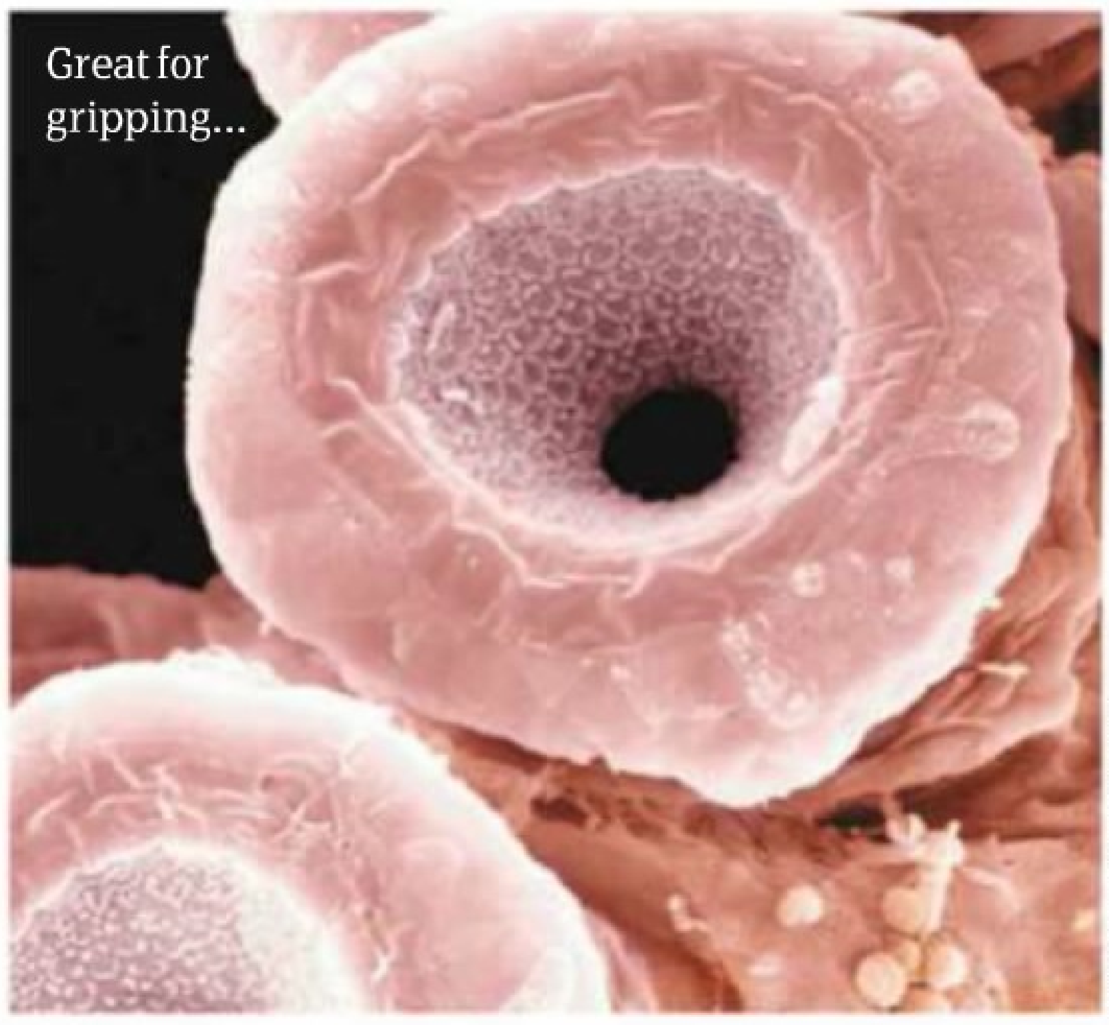
Suckers
Twin rows run the length of the tentacles to allow the octopus to grip and to taste anything it touches.

Jet-propelled

Octopuses normally swim by pulsing their tentacles, like the bell of a jellyfish. This is quite energy efficient but it lacks acceleration, so when an octopus needs a sudden turn of speed it switches to jet propulsion. To do this, they suck water into the mantle cavity and then squirt it at high pressure out of their siphon tube. This is the same way that they circulate water over their gills, so the octopus is really taking a deep breath and then blowing out hard. The siphon is positioned on the side of the octopus's body but it can be steered like the engines of a Harrier jet. Sometimes they use it as a boost when walking as well.

The way forward when the octopus needs a quick burst of speed

© albert kok


Great for gripping...

© Science photo library

Head to Head TYPES OF OCTOPUS

SMART

© Steve Childs

1. Mimic Octopus

To scare predators and fool prey, this octopus changes shape and colour to impersonate snakes, jellyfish and even crabs.

SMARTER

© Beckmannjan

2. Common octopus

Several octopuses in zoos have figured out how to undo screw-top jars to get at food inside.

SMARTEST

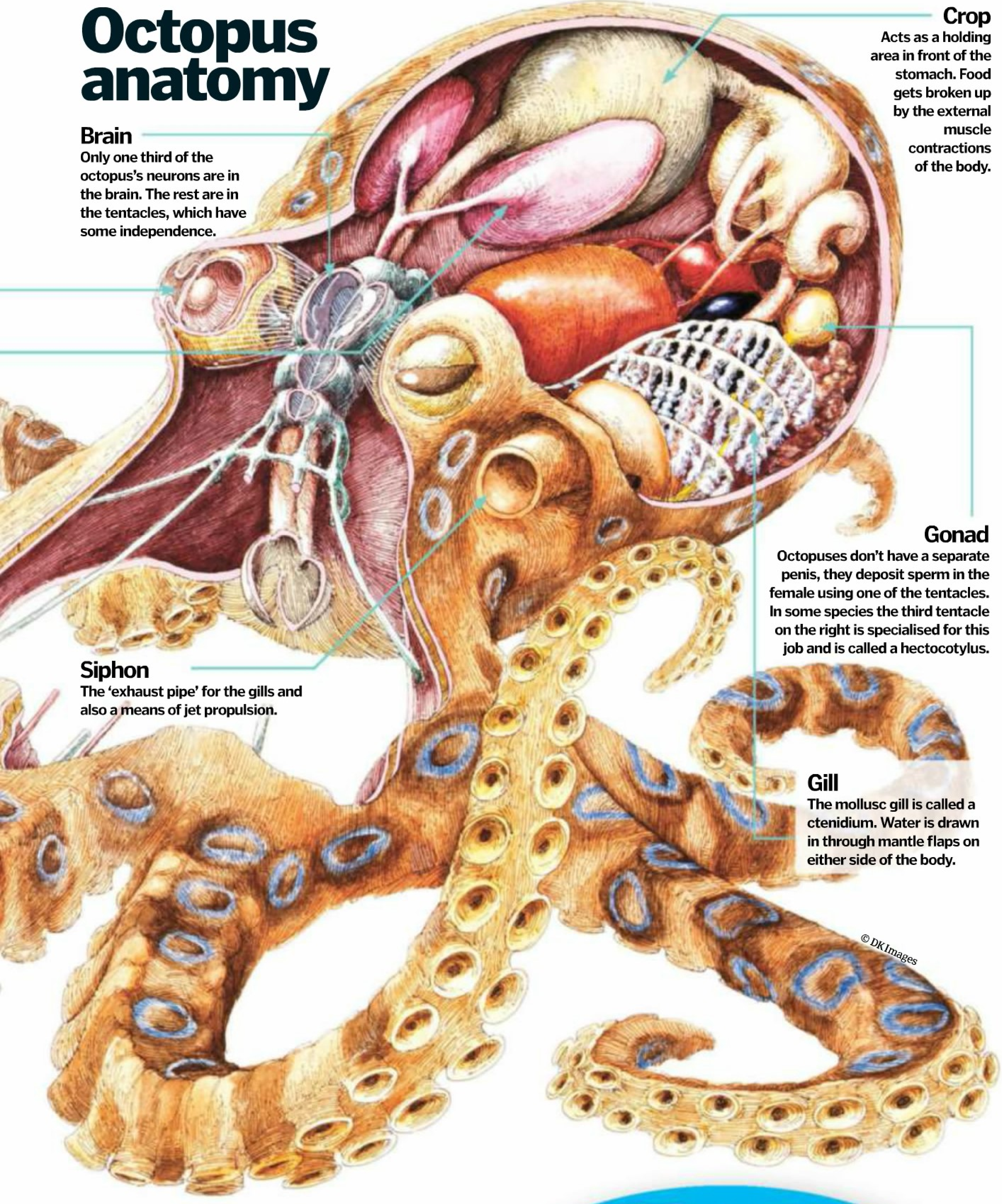
© Nhobgood

3. Coconut octopus

The only invertebrate to demonstrate tool use, the coconut octopus carries around two halves of a coconut shell and climbs inside when threatened.

DID YOU KNOW? Octopuses have three hearts. Two pump blood through the gills, the third serves the rest of the body

Octopus anatomy



Brain
Only one third of the octopus's neurons are in the brain. The rest are in the tentacles, which have some independence.

Crop
Acts as a holding area in front of the stomach. Food gets broken up by the external muscle contractions of the body.

Gonad
Octopuses don't have a separate penis, they deposit sperm in the female using one of the tentacles. In some species the third tentacle on the right is specialised for this job and is called a hectocotylus.

Siphon
The 'exhaust pipe' for the gills and also a means of jet propulsion.

Gill
The mollusc gill is called a ctenidium. Water is drawn in through mantle flaps on either side of the body.

© DK Images

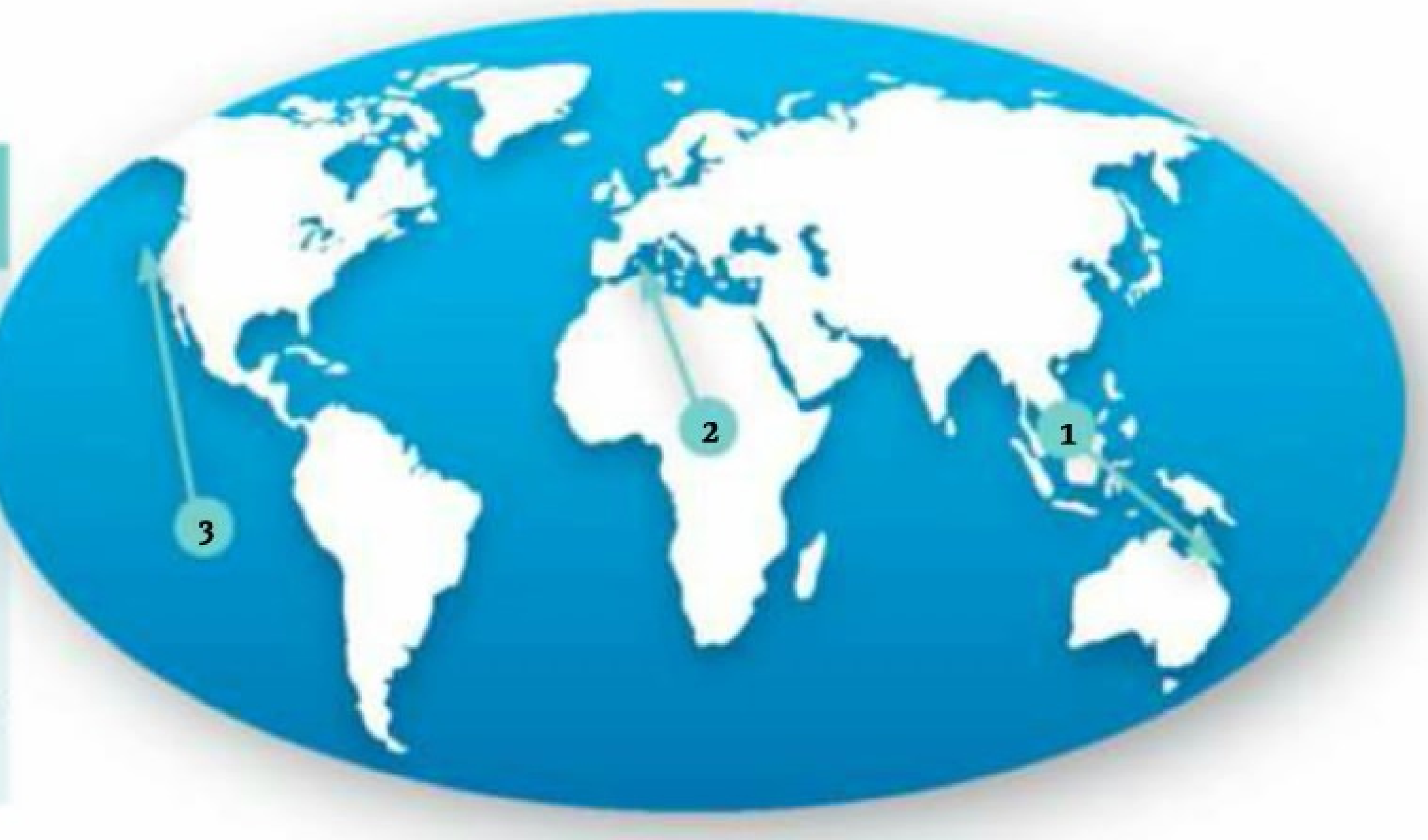
ON THE MAP

Where can you find an octopus?

1 Coral reef – The myriad crevices in a reef are home to lots of tasty creatures but the octopus is very good at winkling them out.

2 Sandy floor – This is more dangerous for an octopus. Some dig burrows in the sand, others use discarded bivalve shells, like a hermit crab.

3 Rocky abyss – The giant North Pacific octopus lives in the deep, freezing depths of the Pacific seabed.



Defences

All octopuses inject a paralysing poison through their beak to subdue prey. The smaller the octopus, the more deadly the poison and the 10cm blue-ringed octopus can kill a human.

Octopuses have lots of predators of their own though, and most of their adaptations are to evade capture. Colour-changing skin cells, called chromatophores, can be used for camouflage or to flash alarming colours to scare predators. Many species also have tiny muscles under the skin to change their texture to resemble spiky coral or fringed seaweed. The mimic octopus will even hold its legs and swim in such a way as to look like a flounder, sea snake or a poisonous lionfish.

If that doesn't work, the octopus can squirt a cloud of melanin dye. This provides a smoke screen and also interferes with the sense of smell that most sharks use to locate prey.

The octopus is far from defenceless

Intelligent legs

With the ability to twist in every direction, and suckers that can grip and release individually, octopus legs are too complicated to be controlled from a central brain. Instead they operate semi-autonomously. An octopus is like a man holding a bunch of trained snakes; he issues instructions and trusts that they will be carried out, occasionally he has a look to make sure. This means that an octopus doesn't have a very good idea of where its legs actually are at any moment and can't work out the shape of something by feeling it, like we can.

Octopuses can taste through their suckers and, if they need to escape, detach a leg and regenerate a new one. One species, the Paper Nautilus, use a leg to deliver sperm. It detaches and swims over to the female by itself.

Do giant squid exist?

Yes they do. A species of squid can reach up to half a ton!

Fiction is commonly built upon myth, however in the year 2007 the tales of maritime folklore were revealed to be true. Exciting the zoological world, a half-ton Architeuthis, or giant squid, was discovered by fishermen in Antarctic waters south of New Zealand. This female measured 33 feet in length and weighed exactly 1,089lbs.

This discovery was significant, as scientists determined the species lives up to 3,000 feet below the surface, descending deeper to 6,500 feet to aggressively hunt prey, with eyes 11-inches wide – useful at depths where light is scarce. Anatomically, this species is found to be a keen predator, with each of its tentacles containing swivelling hooks. Further up these limbs are three razor points, all helping it to attach to prey, including deep-sea fish and other squid species.

Amazingly, after comparing this sea creature's beak with specimens found in the stomachs of sperm whales, researchers believe that Architeuthis can reach up to 46 feet in length.

That's one hell of a portion of calamari

> "Researchers believe that Architeuthis can reach up to 46 feet in length"

Surprisingly the giant squid is the second largest mollusc, behind the legendary Mesonychoteuthis hamiltoni, or colossus squid, believed to measure up to 46 feet long

© Science Photo Library

How do squid swim?

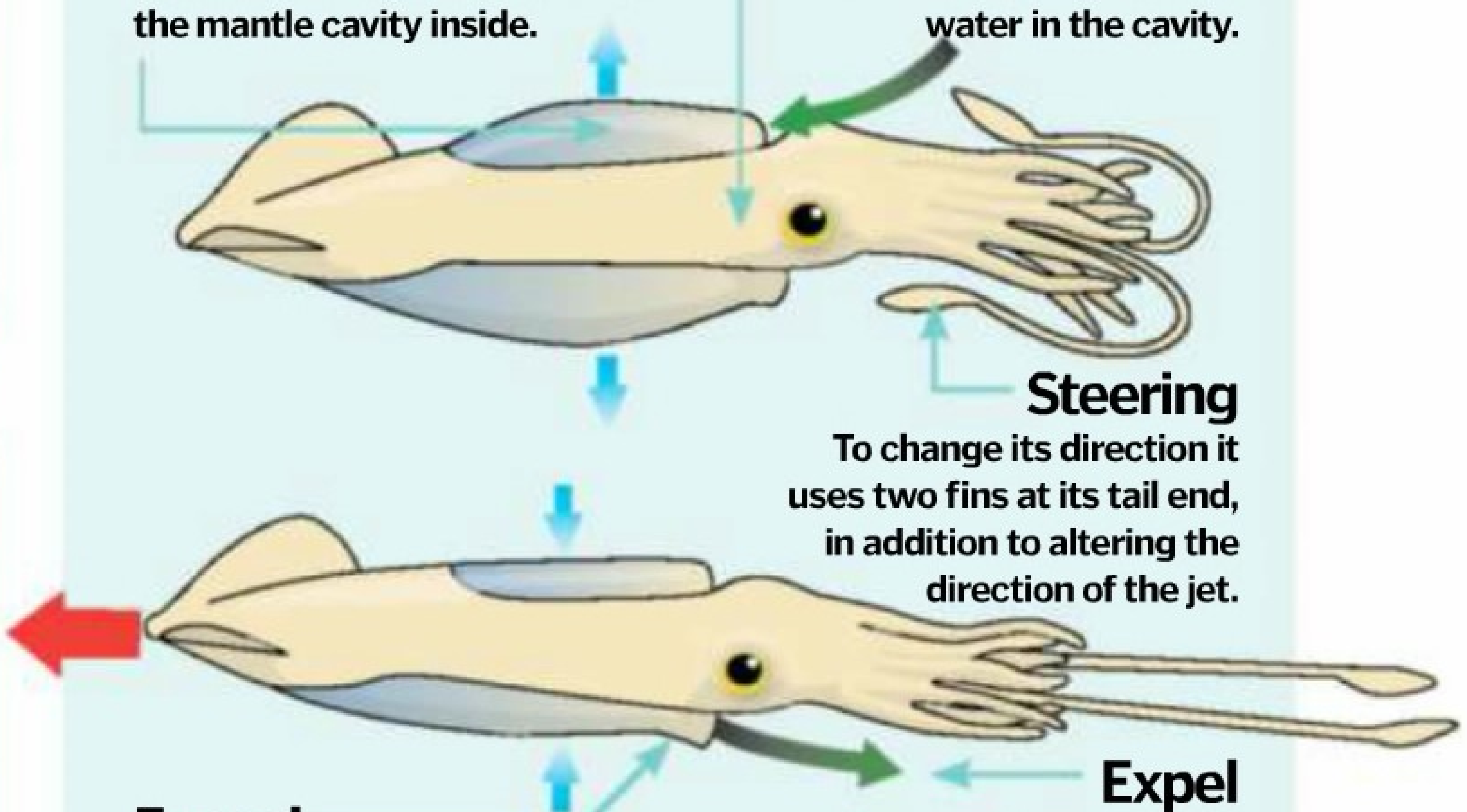
The jet propulsion system that powers squid though water

To move itself through water a squid will emit constant, steady bursts of fluid to provide the necessary acceleration. Squid are able to take water into their mantle and expel it at a high rate, reaching speeds of up to 24mph (40kmh) after expelling 94 per cent of their fluid.

Shaped like a torpedo, the rear body of a squid lets it travel almost like a rocket. By quickly compressing the mantle, a jet of water shoots out behind the squid. The force of this jet moves the squid forwards, allowing it to drift until it comes to a stop, when the process is repeated. To refill the cavity, elastic tissue in the mantle works in tandem with radial muscles to bring in water, in addition to the pressure of incident water as the squid moves. During feeding, the squid swims in the other direction using its arms, allowing it to easily grab prey.

To quickly evade predators, squid can hyperinflate their mantle cavities, expanding them beyond their normal size. This allows for a quick and sudden intake of water that can be rapidly expelled for a fast getaway.

Method of propulsion



Mantle
As the squid prepares to propel itself, the walls of the mantle expand to bring in water, filling the mantle cavity inside.

Cavity
Powerful muscles in the walls of the mantle contract and pressurise the water in the cavity.

Steering
To change its direction it uses two fins at its tail end, in addition to altering the direction of the jet.

Funnel
A one-way valve known as the funnel allows water to be stored for jettison at a later period.

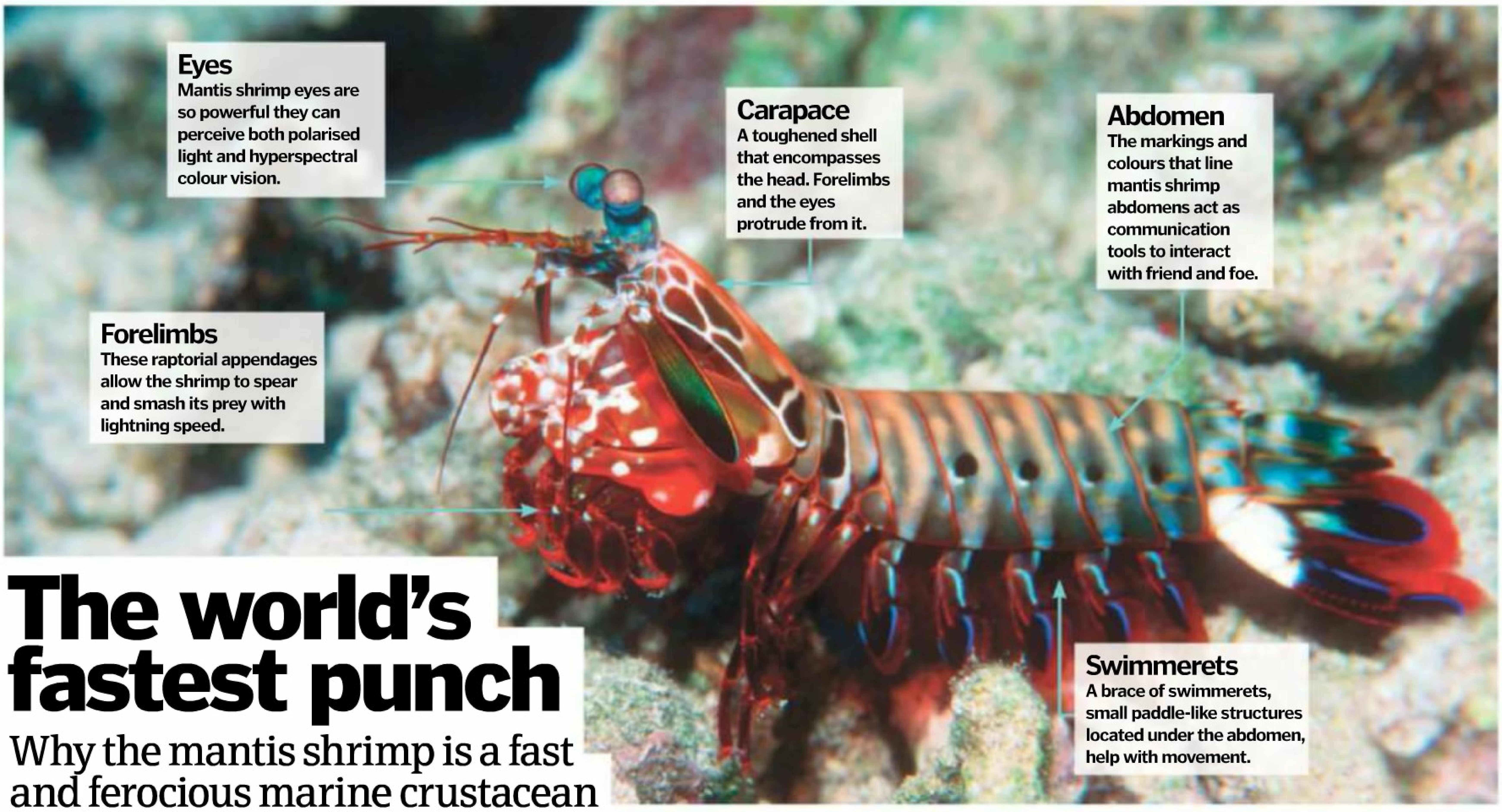
Expel
The water is spurted out near the squid's head, propelling it backwards through the water.

These jet-propelled swimmers can reach speeds of 25mph

© Dan Hershman

The world's fastest punch

Why the mantis shrimp is a fast and ferocious marine crustacean



Eyes
Mantis shrimp eyes are so powerful they can perceive both polarised light and hyperspectral colour vision.

Carapace
A toughened shell that encompasses the head. Forelimbs and the eyes protrude from it.

Abdomen
The markings and colours that line mantis shrimp abdomens act as communication tools to interact with friend and foe.

Forelimbs
These raptorial appendages allow the shrimp to spear and smash its prey with lightning speed.

Swimmerets
A brace of swimmerets, small paddle-like structures located under the abdomen, help with movement.

Mantis shrimp, which are so named due to their resemblance to the praying mantis, are one of the most dangerous creatures in the ocean. Indeed, equipped with an incredible set of eyes comprising up to 10,000 separate apposition-type ommatidia and a pair of raptorial appendages capable of moving at the velocity of a .22-calibre bullet, they are apex predators, capable of smashing and cleaving their prey with brutal efficiency.

The statistics tell you all you need to know in order to realise the destructive capability of these crustaceans. The forelimbs – which come in two main varieties, club or spear-tipped – when unleashed move with an acceleration of 10,400 g, the equivalent of 102,000m/s^2 (335,000ft/s^2), and a speed of 23m/s (75ft/s) from origin. This rapidity is possible because the shrimp generate cavitation bubbles between the appendage and the striking surface that, when collapsed, produce instantaneous forces of 1,500 Newtons on contact as well as a secondary shock wave strike. Consequently, any snail, crab, mollusc or fish (all common in mantis shrimp diets) caught by a blow, will either be horribly skewered or clubbed with immense force.

To maximise their ability to strike prey, mantis shrimp eyes have developed into arguably the most advanced specimens in the world. Each eye, which is mounted on its own individual stalk, possesses trinocular vision and depth perception – the latter especially important for ranging their raptorial appendages. In addition, both eyes can perceive polarised light and hyperspectral colour vision, enabling the shrimp to finely distinguish their prey, which often is transparent or semi-transparent, in brightly coloured coral environments.

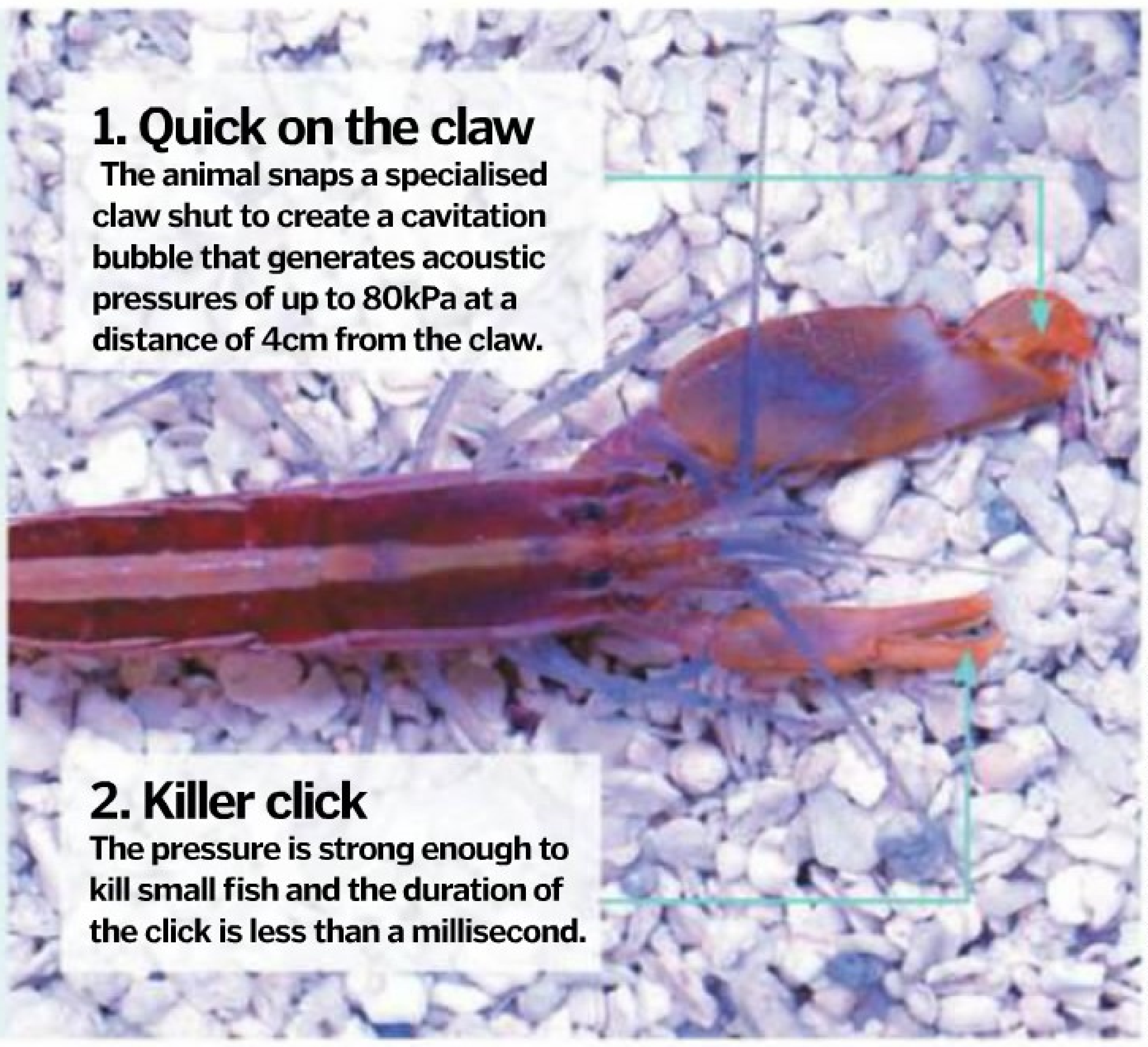
The pistol shrimp

This crustacean armed with its own gun is one of the most deadly residents of the world's oceans

The pistol shrimp apprehends its prey by snapping shut the larger of its two claws at lightning speed, creating a sonic wave that can stun or even kill small fish. The snapping of the claw creates a shock wave that emits a 60mph jet of water, behind which is a bubble of low pressure which then collapses.

It all takes place very quickly, but when the bubble implodes and the temperature inside rises dramatically, a very loud sound is produced, and a tiny spark of light is emitted. The sudden temperature rise – to 4,500°C, almost as hot as the Sun – is produced by the rapid drop in pressure at the point of collapse. The substance then rapidly vaporises within the bubble.

The bubble's collapse also causes a spark of light called sonoluminescence (light emitted from a bubble excited by ultrasound waves), but it's so brief it's not even visible to the naked eye.



1. Quick on the claw
The animal snaps a specialised claw shut to create a cavitation bubble that generates acoustic pressures of up to 80kPa at a distance of 4cm from the claw.

2. Killer click
The pressure is strong enough to kill small fish and the duration of the click is less than a millisecond.

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Measuring three feet from claw to claw the coconut crab is one mighty crustacean

Coconut crabs

A rogue that climbs trees and steals land crabs' burrows, yet still faces extinction

An enormous specimen, weighing up to 5kg, with a body length of up to 40cm and a leg span of 91cm, the Birgus latro is the world's largest terrestrial arthropod. Despite an array of misleading names, it is not a crab. However, we'll refer to it as the coconut crab – so-named due to its ability to climb palm trees and break into coconuts with its pincers (or chelae).

The coconut crab, which can live for up to 30 years, mainly inhabits the forested coastal areas of the islands of the South Pacific and Indian Oceans. A mostly nocturnal crustacean, it hides during the day in underground burrows.

Although coconut crabs mate on dry land, as soon as the eggs are ready to hatch the female releases them into the ocean. Once hatched, the young will visit the ocean floor in search of a shell before coming back to dry land. Once ashore, the coconut crab permanently adapts to life on the land – so much so that it would drown in water because it has developed branchiostegal lungs and special gills more suited to taking oxygen from the air than from water.

The fact that the coconut crab spawns at sea is the main reason for its widespread distribution as currents carry the larvae far afield. Still, the coconut crab remains an endangered species because it is considered a delicacy and is collected as food.

How do barnacles work?

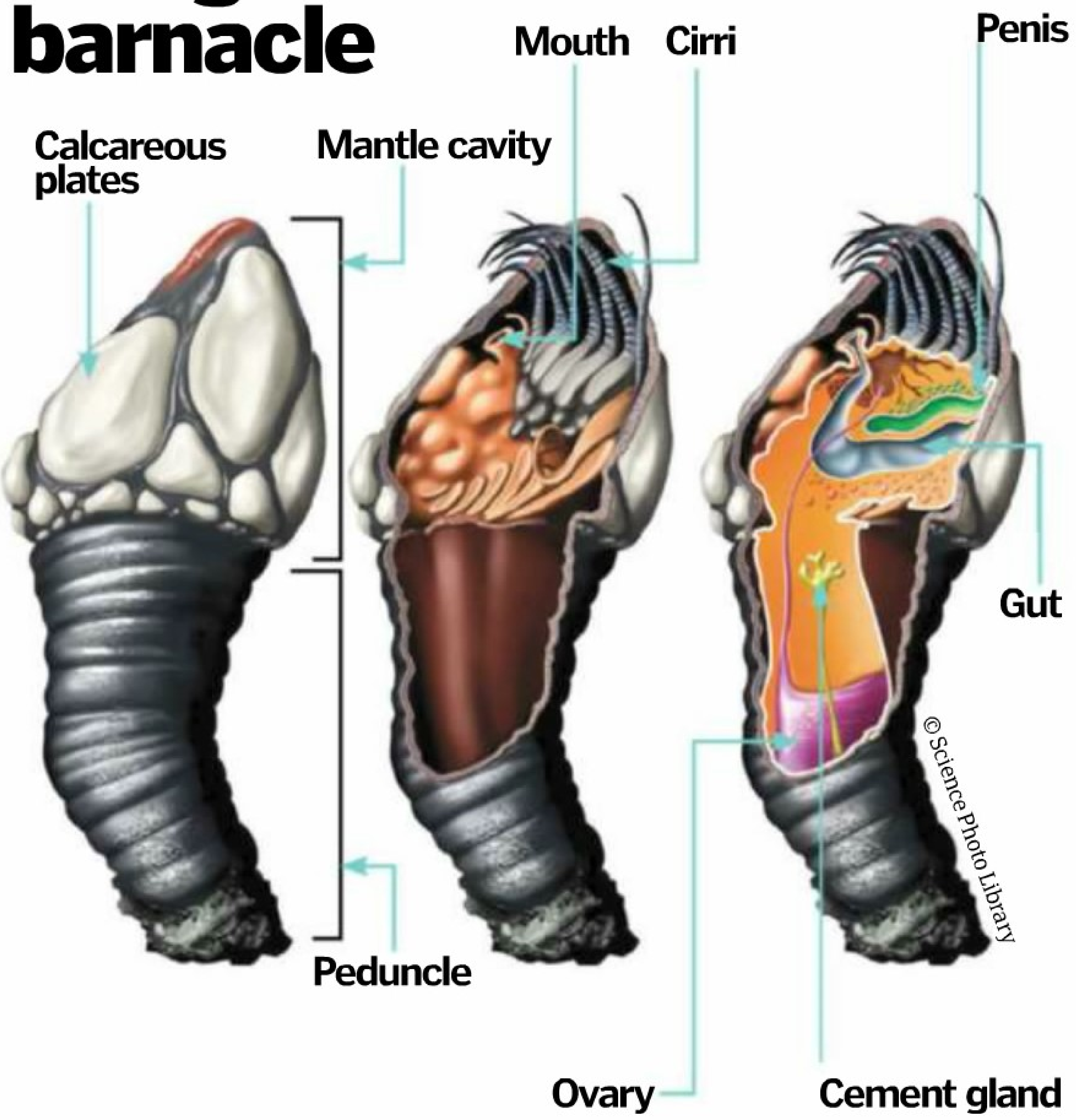
How do these crustaceans survive in the same spot for nearly all their lives?

A barnacle starts out life as a small larva drifting around until it's ready to move into adulthood. At this point, the barnacle resigns itself to a life of immobility by attaching itself to a rock, a boat, or some other large object like a whale. It will then live out its days in the same spot, feeding on particles that float past in the water, such as plankton. The barnacle is a suspension feeder: that is, it uses its wispy, hair-like antennae to catch and filter particles that float by in the water. This process is often good for cleaning the water.

An adult barnacle will stay in the same place for the whole of its three to five-year lifespan. This is due to the very strong cement it uses to fasten itself to an object. In the long, thin peduncle section of the barnacle's body is a cement gland that produces this incredibly adhesive substance.

As you can imagine, being stuck in the same position for their entire lives means that barnacles don't 'get out' much. Each must therefore mate with its nearest neighbour. Despite being a hermaphroditic species (which means they have both male and female reproductive organs) barnacles still have to reproduce with each other. So how exactly do they get around the issue of being fixed to the spot? Well, they are endowed with incredibly long and stretchy penises.

The goose barnacle



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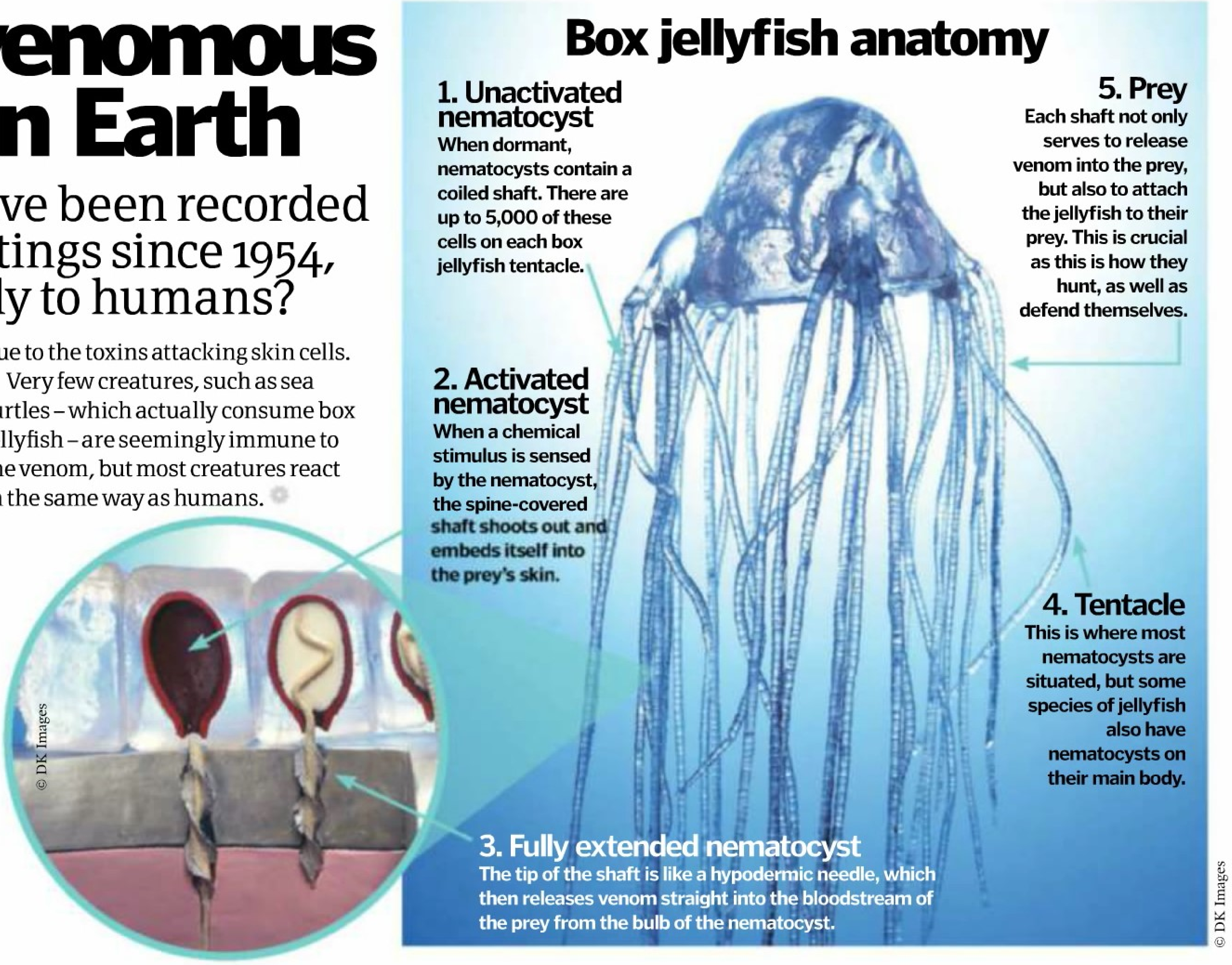
The most venomous creature on Earth

Over 5,500 deaths have been recorded due to box jellyfish stings since 1954, but why is it so deadly to humans?

The box jellyfish is so named due to its box or bell like shape. It has four distinct sides and can have up to 15 tentacles, each one of these stretching up to three metres long with thousands of stinging cells, called nematocysts, on each one. The primary purpose for these nematocysts is to stun and paralyse their prey, ensuring that damage is not sustained to the creature's delicate tentacles. When the venom enters the bloodstream of the stung animal, it quickly targets the nervous system and heart, paralysing them. In humans, cardiac arrest often occurs and the individual will die before they receive aid. Even if they do survive the stings, massive scarring is left where nematocysts have attached due to the toxins attacking skin cells.

Very few creatures, such as sea turtles – which actually consume box jellyfish – are seemingly immune to the venom, but most creatures react in the same way as humans.



Box jellyfish anatomy

1. Unactivated nematocyst
When dormant, nematocysts contain a coiled shaft. There are up to 5,000 of these cells on each box jellyfish tentacle.

2. Activated nematocyst
When a chemical stimulus is sensed by the nematocyst, the spine-covered shaft shoots out and embeds itself into the prey's skin.

3. Fully extended nematocyst
The tip of the shaft is like a hypodermic needle, which then releases venom straight into the bloodstream of the prey from the bulb of the nematocyst.

4. Tentacle
This is where most nematocysts are situated, but some species of jellyfish also have nematocysts on their main body.

5. Prey
Each shaft not only serves to release venom into the prey, but also to attach the jellyfish to their prey. This is crucial as this is how they hunt, as well as defend themselves.

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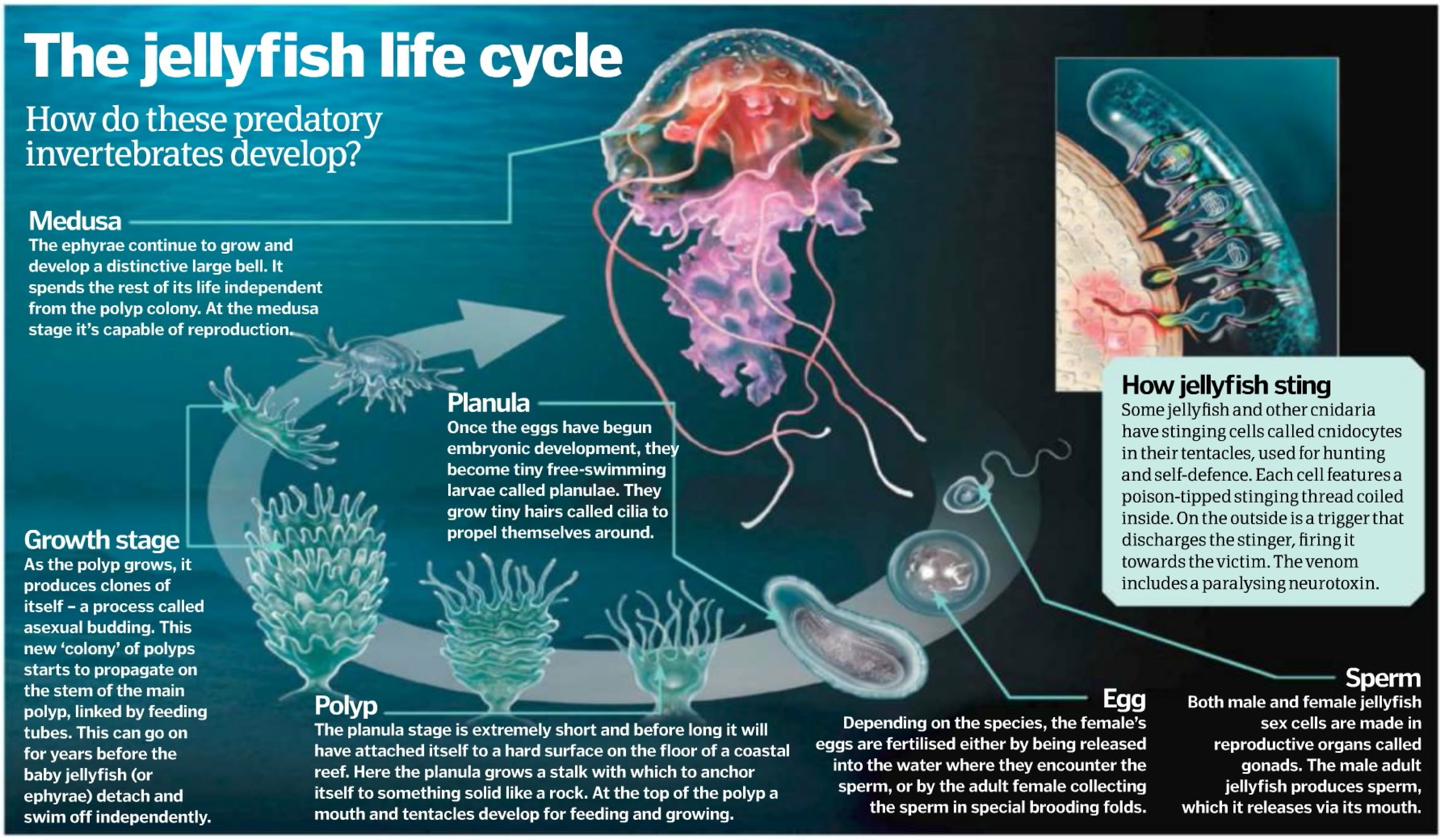


The jellyfish life cycle

How do these predatory invertebrates develop?

Medusa
The ephyrae continue to grow and develop a distinctive large bell. It spends the rest of its life independent from the polyp colony. At the medusa stage it's capable of reproduction.

Planula
Once the eggs have begun embryonic development, they become tiny free-swimming larvae called planulae. They grow tiny hairs called cilia to propel themselves around.

Growth stage
As the polyp grows, it produces clones of itself – a process called asexual budding. This new 'colony' of polyps starts to propagate on the stem of the main polyp, linked by feeding tubes. This can go on for years before the baby jellyfish (or ephyrae) detach and swim off independently.

Polyp
The planula stage is extremely short and before long it will have attached itself to a hard surface on the floor of a coastal reef. Here the planula grows a stalk with which to anchor itself to something solid like a rock. At the top of the polyp a mouth and tentacles develop for feeding and growing.

Egg
Depending on the species, the female's eggs are fertilised either by being released into the water where they encounter the sperm, or by the adult female collecting the sperm in special brooding folds.

Sperm
Both male and female jellyfish sex cells are made in reproductive organs called gonads. The male adult jellyfish produces sperm, which it releases via its mouth.

How jellyfish sting
Some jellyfish and other cnidaria have stinging cells called cnidocytes in their tentacles, used for hunting and self-defence. Each cell features a poison-tipped stinging thread coiled inside. On the outside is a trigger that discharges the stinger, firing it towards the victim. The venom includes a paralysing neurotoxin.

© SPL

Coral reefs

Incredible biological richness in the most nutrient-poor waters in the world? The paradox of the coral reef is explained...

The secret to understanding how coral reefs work is that they flourish in tropical waters that contain hardly any food. They are often described as the rainforests of the ocean but it is more accurate to think of them as oases in a saltwater desert. Warm water doesn't dissolve nutrients very well so it doesn't support the soup of plankton that exists in colder waters. But this means that the water is also very clear, which makes it ideal for photosynthesis. By striking up a symbiotic allegiance with photosynthetic zooxanthella bacteria, the corals can harness the sunlight to provide them with most of their food, while at the same time retaining their animal ability to capture small prey and gather essential nitrogen.

The limestone skeleton that corals produce to protect themselves also dramatically affects the ocean environment. It absorbs and deflects wave energy, creating sheltered lagoons in its lee and provides innumerable crevices and attachment points for other animals. A reef is a complex ecosystem with each species contributing to the stability of the whole. Algae help cement the reef together, sea urchins keep the algae under control, molluscs stop the sea urchins from overgrazing, and so on.

Over geological timescales, coral reefs grow so as to regulate the depth of the water above them, even during times of rising sea level. This prevents the ecosystem from simply 'drowning' in the increasing gloom and makes coral reefs some of the most long-lived biological structures on the planet. Some coral atolls are 30 million years old.

Colourful soft corals, anthias. moray eel and other fish species

5 TOP FACTS REEF DWELLERS

Dwarf seahorse

1 The slowest fish in the world. Never straying far from the safety of its nest crevice, this fish swims at just five feet per hour, that's an incredibly slow 0.0004m/s.

Seven-figure pygmy goby

2 The high risk of predation on the reef encourages this fish to live fast and die young. It is the shortest-lived vertebrate with a natural life span of just 59 days.

Yellowfin goatfish

3 At night, this bottom feeder trawls the sands for worms and crustaceans. But by day it changes colour and hides among shoals of bluestriped snapper.

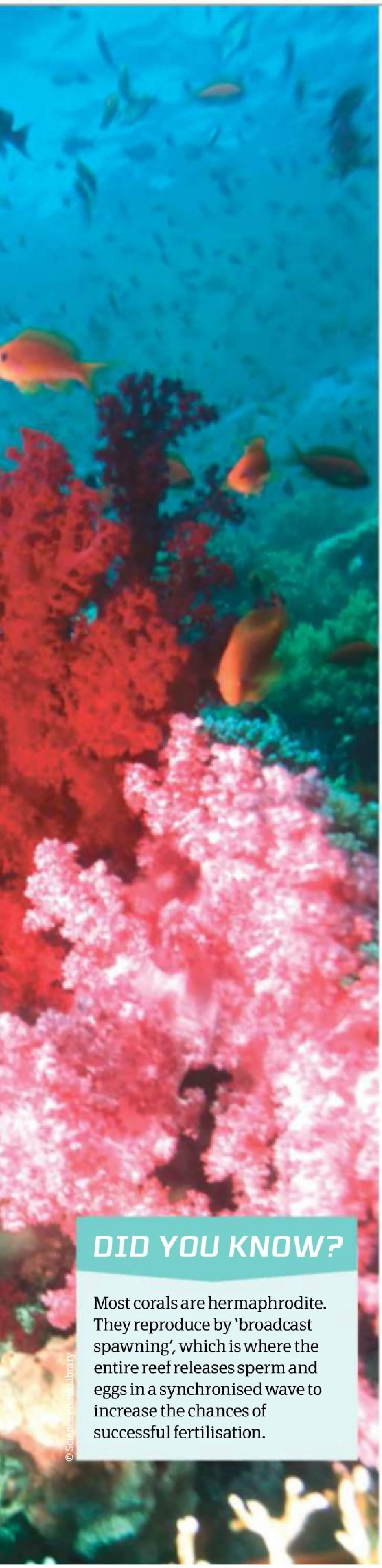
Crown-of-thorns

4 This starfish grows up to 40cm across and each one can eat up to six square metres of living coral a year. It is the second largest sea star in the world.

Giant triton

5 A giant sea snail and one of the only predators of the crown-of-thorns. The triton is in decline because of overfishing for its huge 50 centimetre shell.

DID YOU KNOW? 60 per cent of the world's coral reefs are at risk of destruction. Ten per cent are already dead



© Science Photo Library

DID YOU KNOW?

Most corals are hermaphrodite. They reproduce by 'broadcast spawning', which is where the entire reef releases sperm and eggs in a synchronised wave to increase the chances of successful fertilisation.

Types of coral reef

Reefs form in shallow waters close to the shore. At the end of the last ice age, 10,000 years ago, the sea level began to rise. In order to keep close enough to the surface for photosynthesis, the coral reefs grew upward. They also grew outwards but because the sheltered conditions on the shoreward side of the reef are less favourable, they grew more slowly there. This, combined with the shrinking shoreline as the sea level rises, causes the reef to separate from the shore.

With enough time, erosion and rising seas may remove the central island altogether and all that is left is a coral atoll.

1. Volcano
An undersea volcanic eruption erupts enough lava to create an island that juts above the surface.

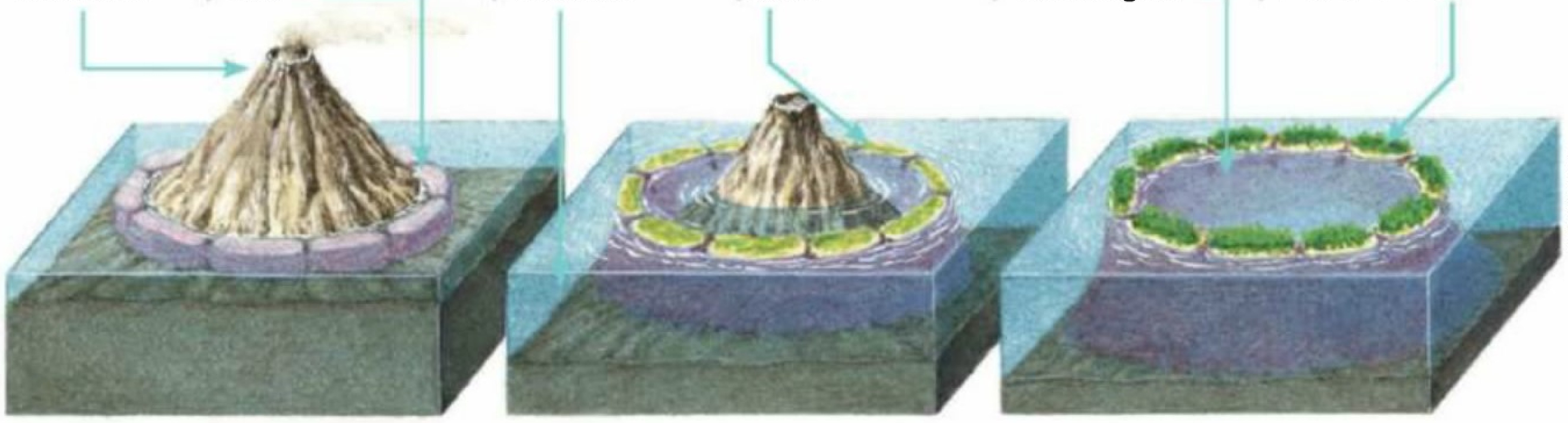
2. Fringing reef
The shallow seas near the shoreline and the turbulence from the wave action encourages the formation of a fringing reef.

3. Rising sea
Over time, the sea level rises, shrinking the portion of the extinct volcano that juts above the water.

4. Barrier reef
The coral grows upward, to stay close to the surface. A sheltered lagoon now forms between the coral and the shore.

5. Atoll
Eventually the volcano may become completely submerged, leaving a ring or partial ring of coral around a shallow lagoon.

6. Plant life
Broken coral and animal shells form sand that collects in the gaps between the coral. Plants take root, stabilising and raising the ground level.



© DK Images

What's inside coral?

Coral looks and behaves rather like a plant but it is actually a colony of animals, related to sea anemones, called polyps. Each polyp anchors itself to the existing reef and builds a calcium carbonate skeleton to protect its body. Successive generations of polyps build on the dead skeletons of the one before as the reef grows.

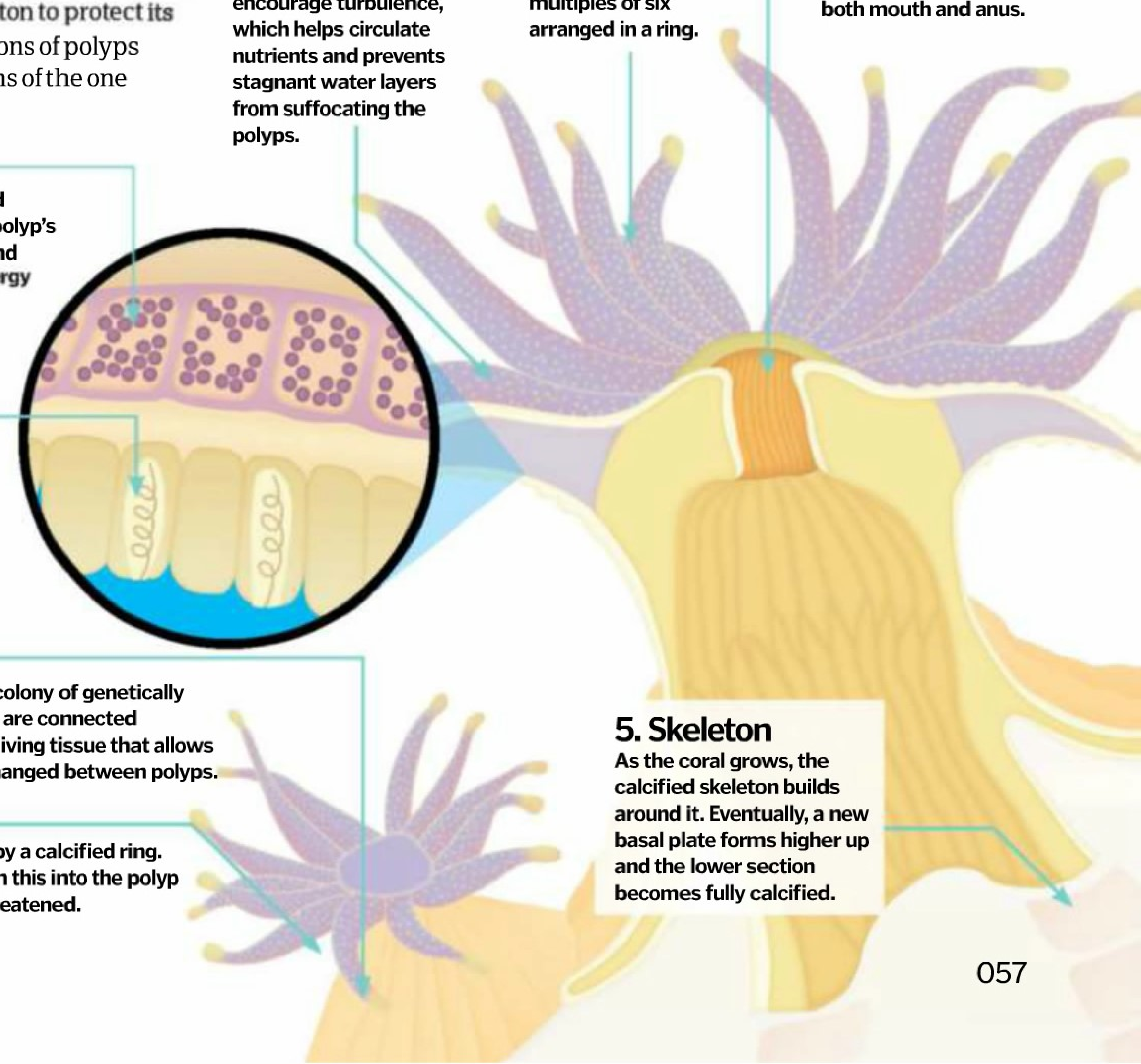
8. Rough surface
Coral skeletons are deliberately rough to encourage turbulence, which helps circulate nutrients and prevents stagnant water layers from suffocating the polyps.

1. Tentacles
Reef building corals have tentacles in multiples of six arranged in a ring.

3. Mouth
Polyps only have one opening to their stomach cavity. This serves as both mouth and anus.

6. Zooxanthellae
Photosynthetic bacteria called zooxanthellae live within the polyp's tissues. These trap sunlight and provide 90 per cent of the energy requirements of the coral. In return, the polyp supplies nitrogen and carbon dioxide.

2. Nematocysts
Stinging cells in the tentacles, called nematocysts, are used to catch zooplankton that drift by. Each nematocyst can fire only once and then must be replaced.



7. Living tissue
A 'head' of coral consists of a colony of genetically identical cloned polyps. These are connected together by a surface layer of living tissue that allows metabolic products to be exchanged between polyps.

4. Basal plate
The polyp is glued to the reef by a calcified ring. Muscular ridges protrude from this into the polyp and can retract it quickly if threatened.

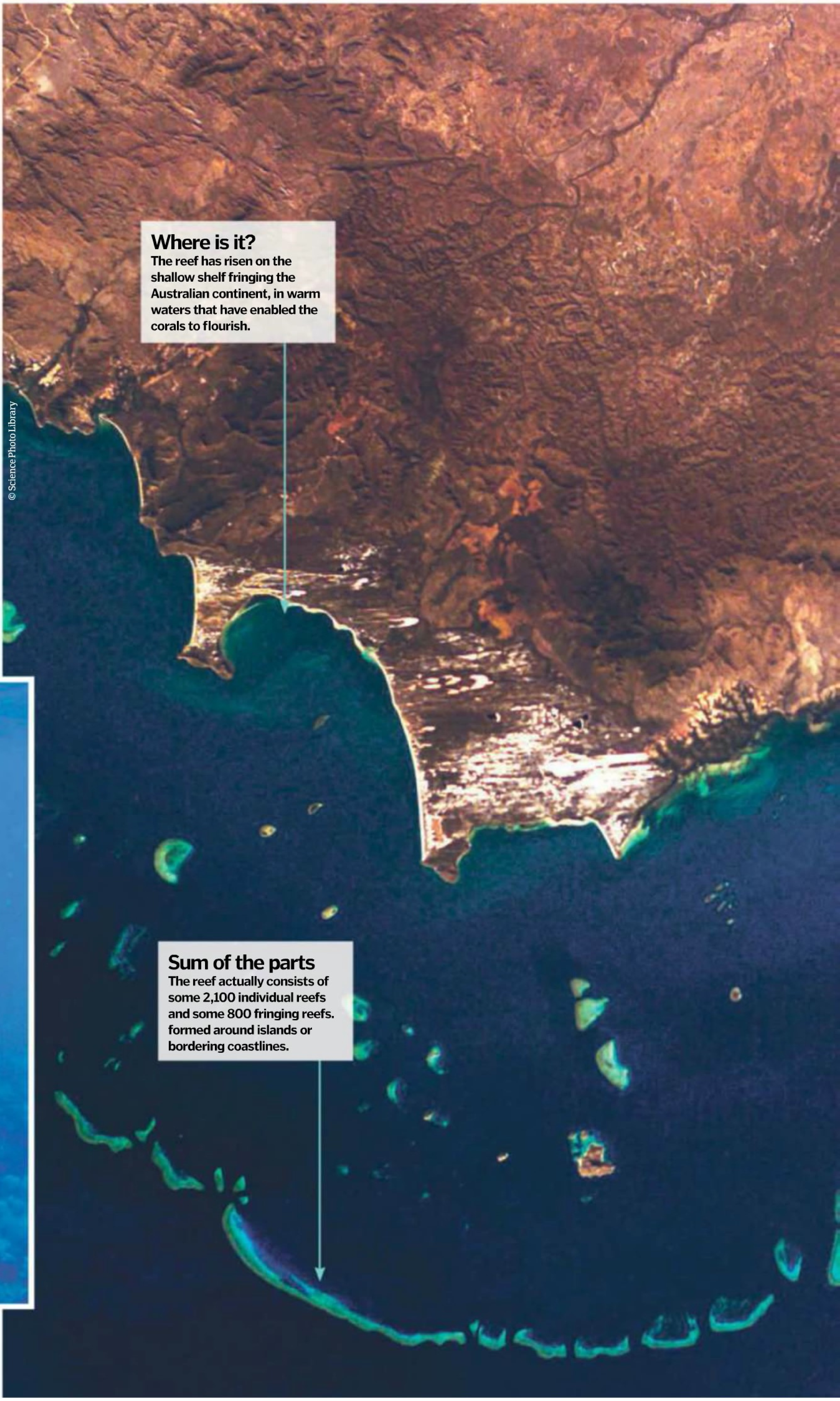
5. Skeleton
As the coral grows, the calcified skeleton builds around it. Eventually, a new basal plate forms higher up and the lower section becomes fully calcified.

Great Barrier Reef

It's a big one down under...

The Great Barrier Reef is the largest structure in the world made by living organisms and covers 344,400 square kilometres. Coral reefs have existed off the north coast of Australia for at least 18 million years, but the formation of the modern reef began about 20,000 years ago. As sea levels rose by 120m over the next 14,000 years, the corals formed reefs around the flooded coastal hills, which became islands and eventually disappeared completely. The Great Barrier Reef is home to whales, dolphins, dugongs, sharks, turtles and giant clams. Fishing and tourism together account for around £1.2 billion each year.

The reef was declared a Marine Park in 1975, to provide long term protection for the many species that live there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Where is it?
The reef has risen on the shallow shelf fringing the Australian continent, in warm waters that have enabled the corals to flourish.

Sum of the parts
The reef actually consists of some 2,100 individual reefs and some 800 fringing reefs. formed around islands or bordering coastlines.

Head to Head
BIGGEST CORAL REEFS

1. East Rennell Island

At 86km by 15km, this is the largest raised coral atoll in the world. Its lagoon is also the largest in all the Pacific islands.

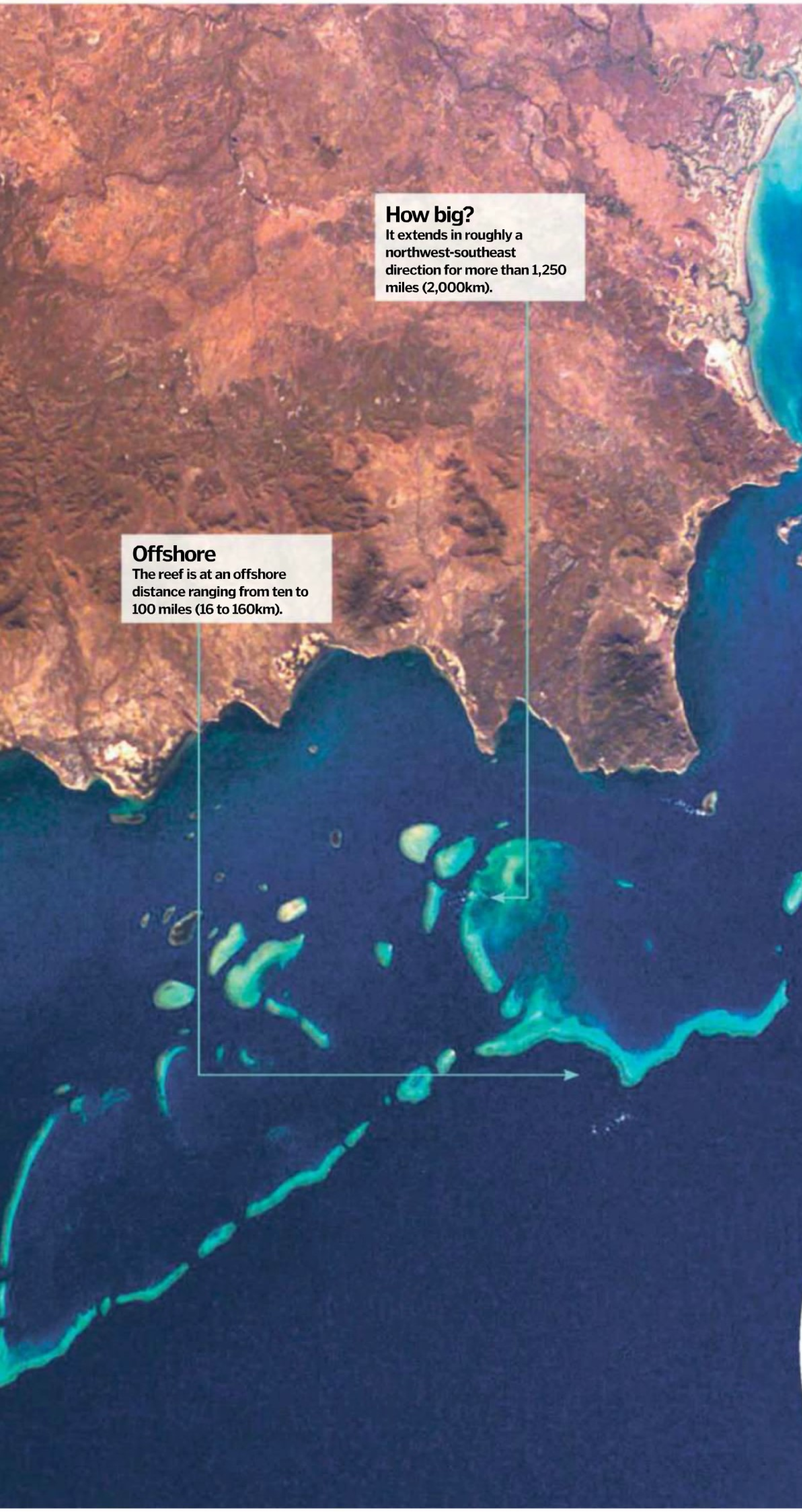
2. Belize Barrier Reef

The largest barrier reef in the northern hemisphere. The reef system includes hundreds of sand cays (low islands) and lagoons.

3. Great Barrier Reef

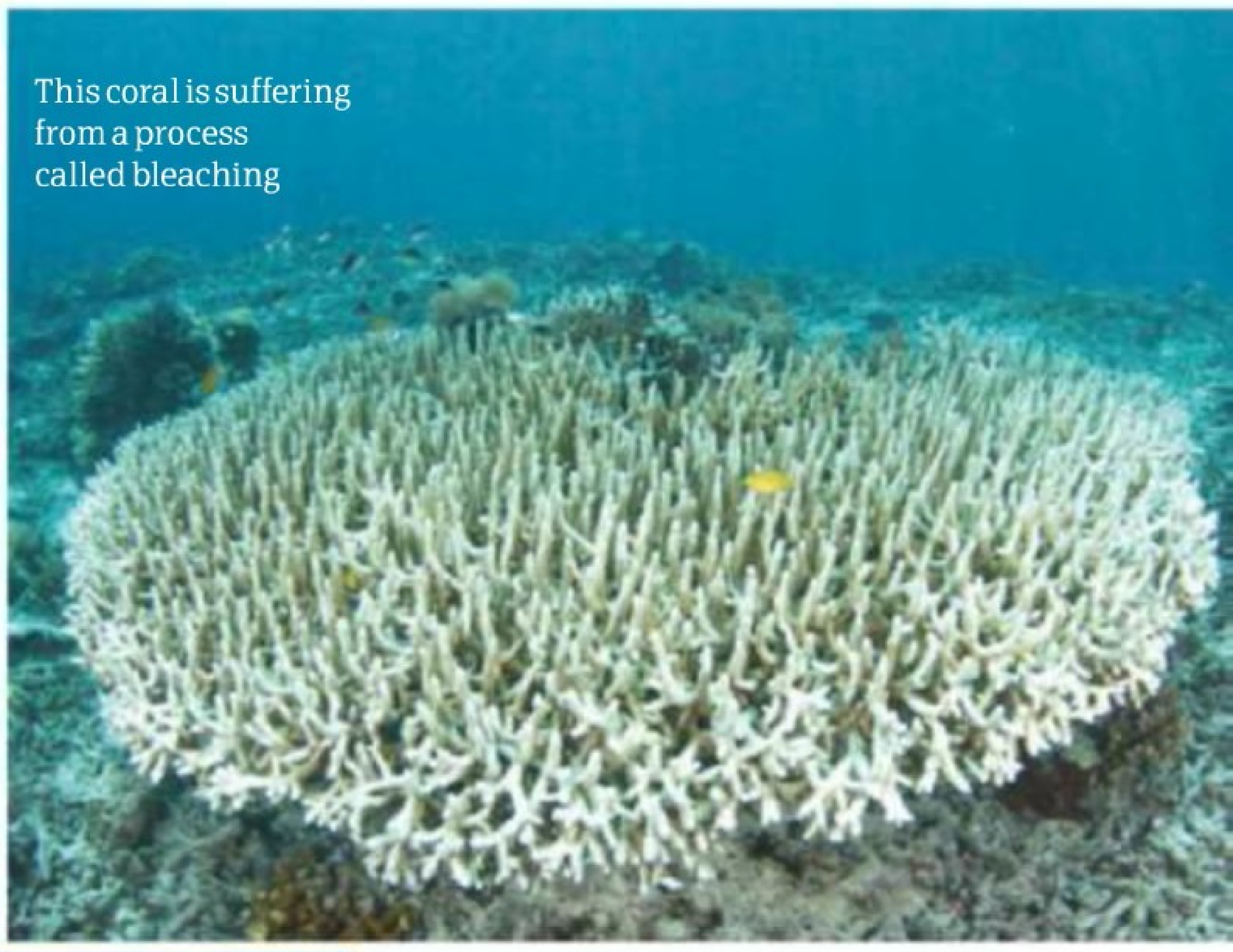
The largest reef in the world. It is 2,600km long, incorporates 940 islands and is visible from outer space.

DID YOU KNOW? *Two-thirds of the global population of the Laysan Albatross [1.5 million birds] nest on the Midway Atoll*



How big?
It extends in roughly a northwest-southeast direction for more than 1,250 miles (2,000km).

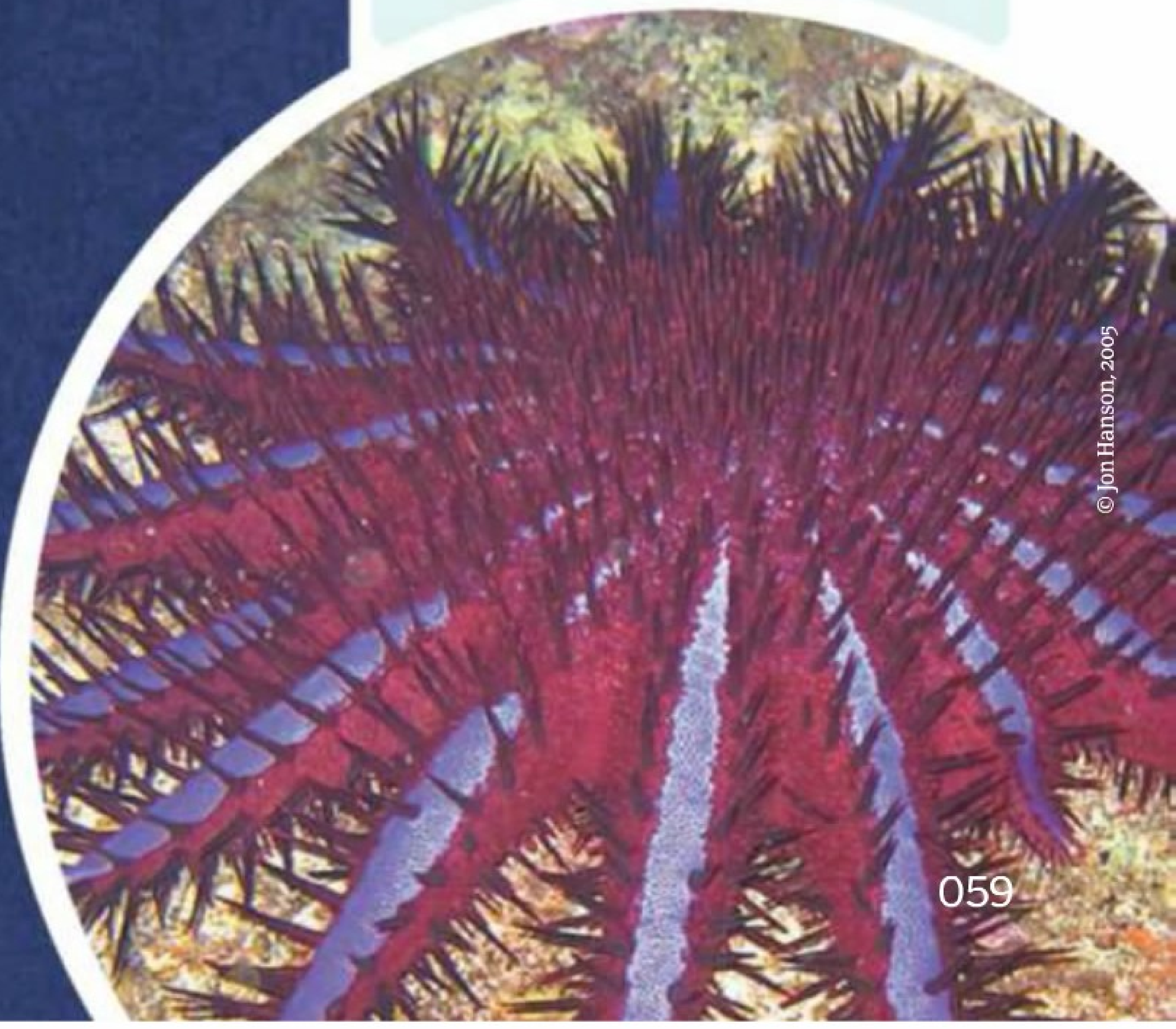
Offshore
The reef is at an offshore distance ranging from ten to 100 miles (16 to 160km).



This coral is suffering from a process called bleaching

Threats to the coral reef

Corals are very sensitive to changes in sea temperature and water quality. When stressed, corals will eject their symbiotic zooxanthella bacteria in an attempt to conserve energy – a process known as coral bleaching. If the unfavourable conditions do not improve within a few months, the coral will not acquire new symbionts and will die. Global climate change is raising ocean temperatures; increasing the frequency of bleaching events. Rising carbon dioxide levels also make the seawater more acidic, which inhibits the formation of calcium carbonate skeletons. Corals are also threatened by fertiliser run-off from farms, and destructive fishing practices such as dynamiting.



© Jon Hanson, 2005

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Plant life of the coral reef

There are three main kinds of coral plants. The familiar seaweeds (or macroalgae) are found in the shallowest waters, usually on the top of the reef. Turf algae are short filaments that form carpets usually less than one centimetre high. These are an important food source for reef herbivores because they grow very quickly.

The crustose coralline algae don't look like plants, they appear as red or pink splashes of paint, coating the surface of the coral. These thin sheets of plant life have cells reinforced with calcium carbonate, just like the corals. They favour the outer face of a reef, where the wave action is most aggressive and are important in cementing the reef together.

Creatures of the coral reef

Coral reefs support an amazing array of animals and creatures

Coral reefs cover just one per cent of the ocean's surface area, but they account for 25 per cent of its biodiversity. Compared to the placid and largely empty deep waters around it, a coral reef boils with life. As well as 8,000 species of fish, coral reefs are home to sponges, crustaceans, starfish, turtles and sea snakes. Some, like the crown-of-thorns sea star, eat the coral directly but most reef creatures are active predators. This, coupled with such a tightly knit environment, leads to a frantic, cut-throat existence.

Reef fish, like the queen angelfish, are adapted to fit into tiny crevices and are often highly flattened, using their pectoral fins to paddle around in short spurts, rather than the energy-efficient cruising of open water fish like tuna. Because of the enclosed nature of a reef, swimming speed is less of a consideration than close range defences. Reef fish are often brightly coloured and this may be to camouflage themselves against the equally bright corals or to confuse predators with false eyespots, such as those of the foureye butterflyfish. Many fish have poisonous spines to make themselves less appetising. Gobies have eyes that can swivel independently, like a chameleon, to let them scan for predators.

© Laszlo Ilyes, 2006

A queen angelfish is perfectly adapted to reef living

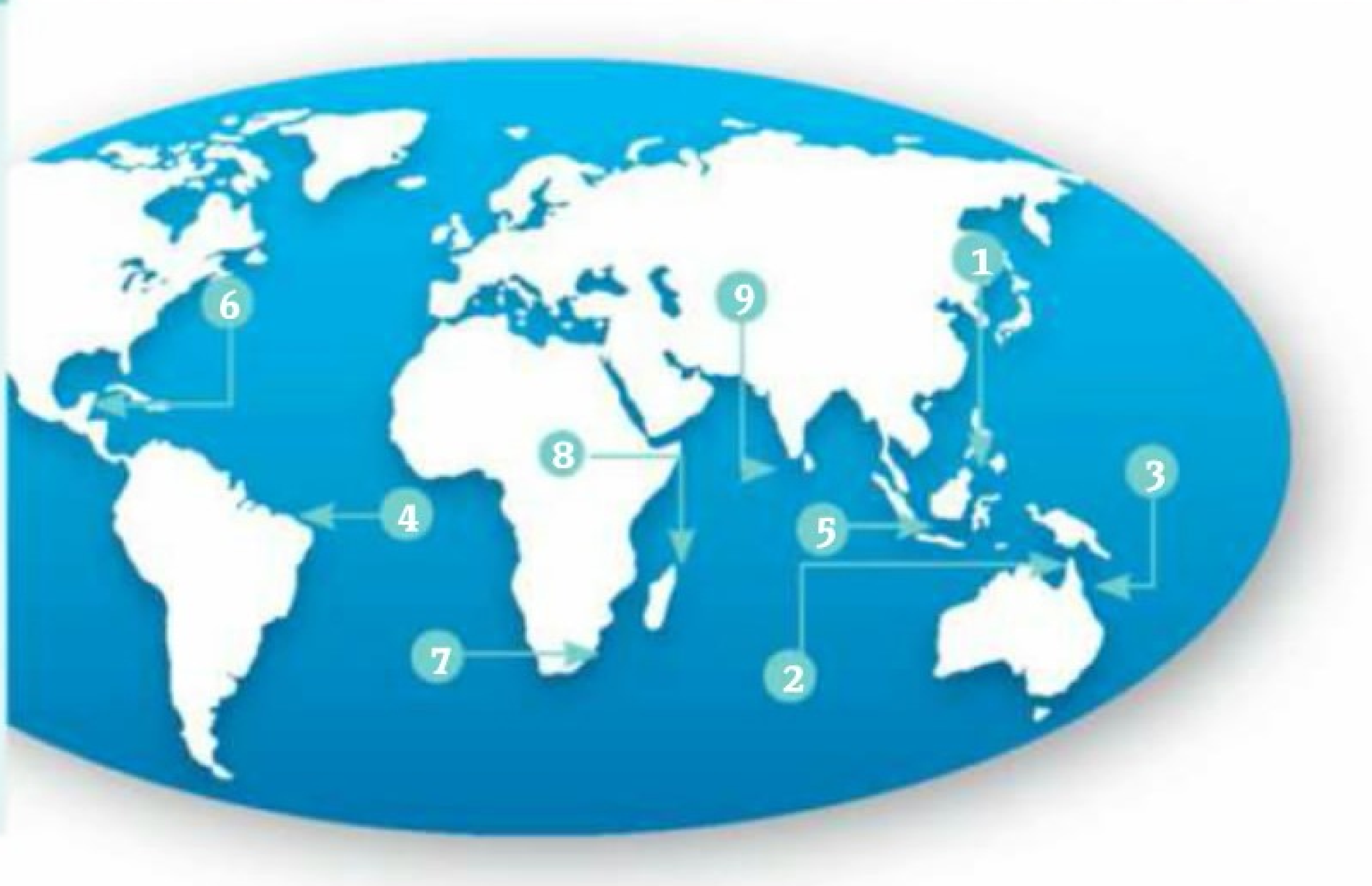
Easy come, easy goby. A common resident of the coral reef

ON THE MAP

Where do coral reefs grow?

Looking for the largest organisms on Earth? Look here

1. Tubbataha Reef Marine Park
2. Great Barrier Reef
3. East Rennell Island
4. Brazilian Atlantic islands
5. Komodo National Park
6. Belize Barrier Reef
7. Greater St Lucia Wetland Park
8. Aldabra Atoll
9. Maldives



THE STATS STARFISH

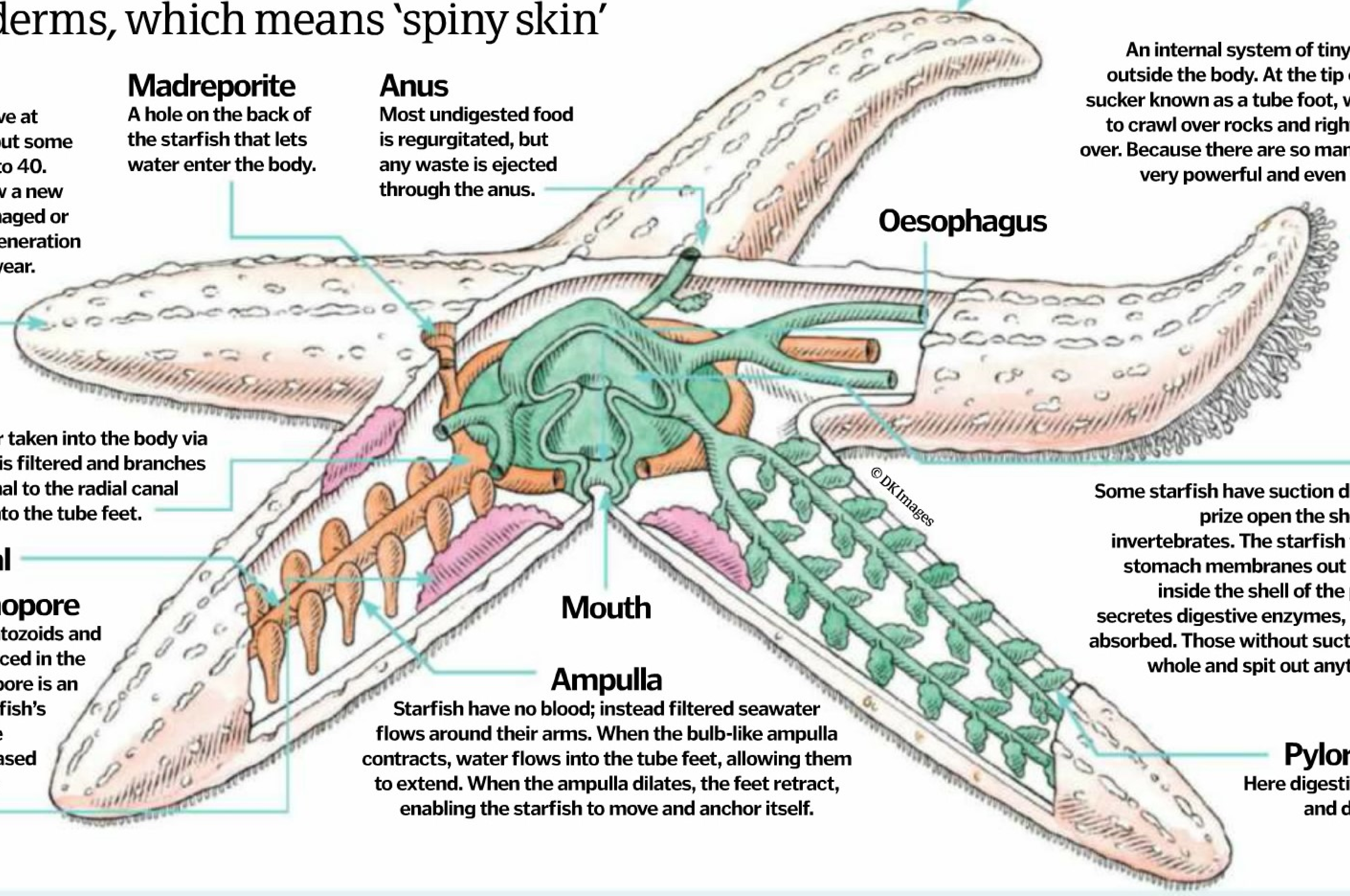
SPECIES 1,800 **LARGEST** 9.4 in (24cm) **DEEPEST** 6,000m

OLDEST 35 yrs **HEAVISEST** 111bs (5kg) **FASTEST** 2.5 feet p/min

DID YOU KNOW? A starfish can crawl at speeds of up to 2.5 feet per minute if pursuing prey. All the participants in the ancient Olympics, for the first several centuries of the competition, were aristocrats

Starfish anatomy

Discover the inner workings of these carnivorous creatures called echinoderms, which means 'spiny skin'



Skin
A starfish has no head and no brain; instead it uses sensitive skin cells to detect smells and chemicals from food, special eye spots at the end of each arm can also detect light. These remarkable sense cells send signals through a system of nerves.

Tube feet
An internal system of tiny flexible pipes extends outside the body. At the tip of each tube is a sticky sucker known as a tube foot, which the starfish uses to crawl over rocks and right itself if it gets flipped over. Because there are so many of them, they can be very powerful and even help them open shells.

Arms
Most starfish have at least five arms, but some species have up to 40. Starfish can grow a new arm if one is damaged or amputated – regeneration can take up to a year.

Madreporite
A hole on the back of the starfish that lets water enter the body.

Anus
Most undigested food is regurgitated, but any waste is ejected through the anus.

Ring canal
Filtered seawater taken into the body via the madreporite is filtered and branches from the ring canal to the radial canal before passing into the tube feet.

Radial canal

Gonad/Gonopore
Sex cells (spermatozoids and ovules) are produced in the gonad. The gonopore is an opening on a starfish's back where these gametes are released into the water for fertilisation.

Ampulla
Starfish have no blood; instead filtered seawater flows around their arms. When the bulb-like ampulla contracts, water flows into the tube feet, allowing them to extend. When the ampulla dilates, the feet retract, enabling the starfish to move and anchor itself.

Stomach
Some starfish have suction discs, which they use to prize open the shells of clams and other invertebrates. The starfish then pushes its supple stomach membranes out through its mouth and inside the shell of the prey. The starfish then secretes digestive enzymes, which allow food to be absorbed. Those without suction discs swallow prey whole and spit out anything they can't digest.

Pyloric duct/cecum
Here digestive juices are produced and digested food is stored.

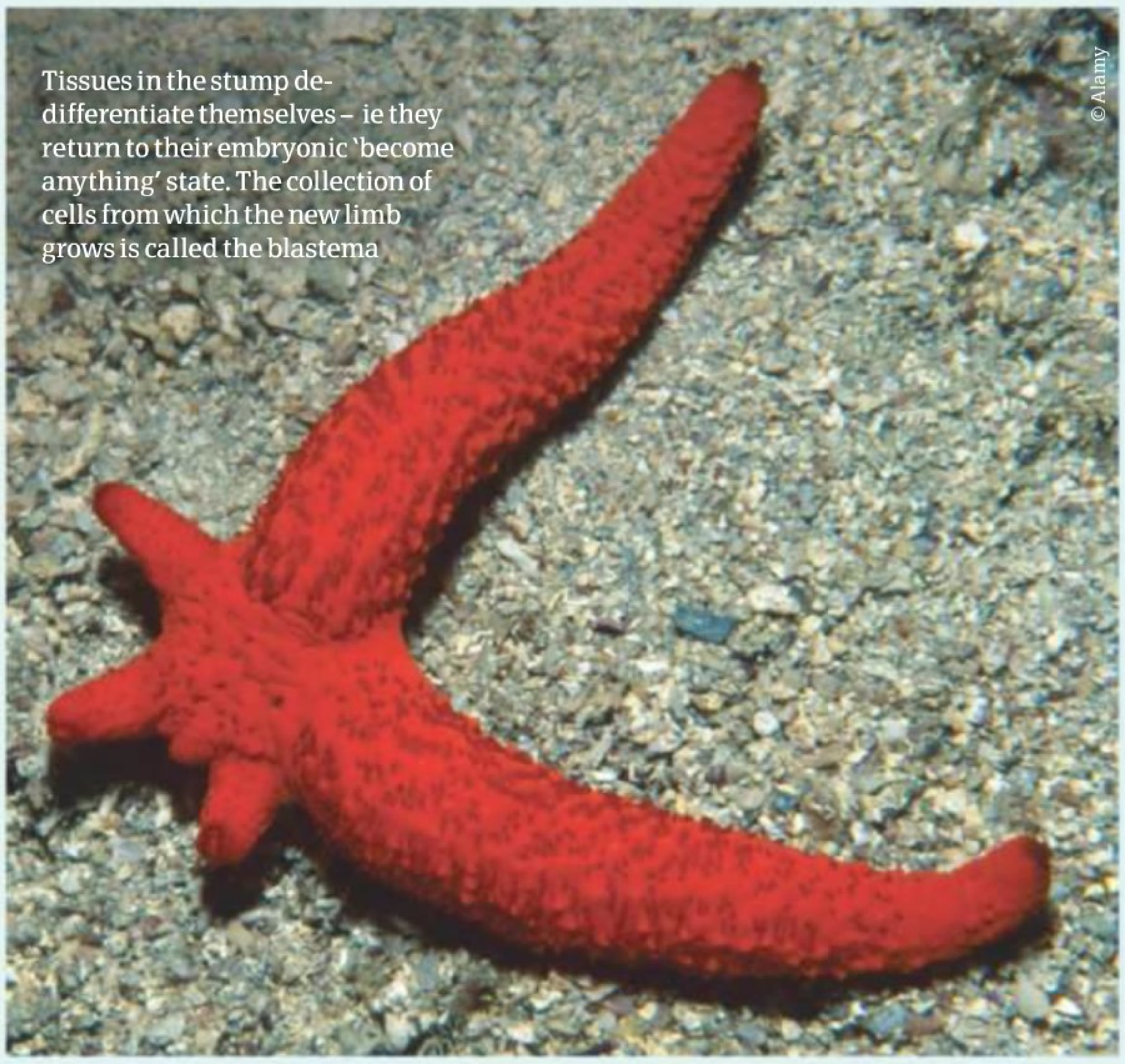
How do animals regenerate limbs?

Learn how some creatures have a natural ability to regrow certain body parts

One of nature's most intriguing biological miracles is the amazing ability to regrow damaged or severed body parts. Animals including seastars, salamanders, planarians (flatworms), crabs and some fish are all capable, to varying degrees, of body part regeneration, ranging from limbs to tails, and on to even eyes and internal organs.

The process all starts with the clever cells we humans have when we're growing in the womb: namely stem cells. Embryonic stem cells are those that do not yet have a speciality – that is, they can potentially become any cell, such as bone, muscle or nerve tissue.

Creatures that can regenerate new body parts remodel themselves into their original physical form by reactivating the cells near the wound site and instructing them to behave like stem cells. Some animals can retain bundles of these embryonic stem cells in their bodies, which – in the event of amputation – migrate to and proliferate around the wound where they get to work rebuilding the missing or damaged body part, just as if it were a growing foetus.



Tissues in the stump de-differentiate themselves – ie they return to their embryonic 'become anything' state. The collection of cells from which the new limb grows is called the blastema

© Alamy

Life in a rock pool

Rock pools may only be small bodies of water, but they are full of marine life

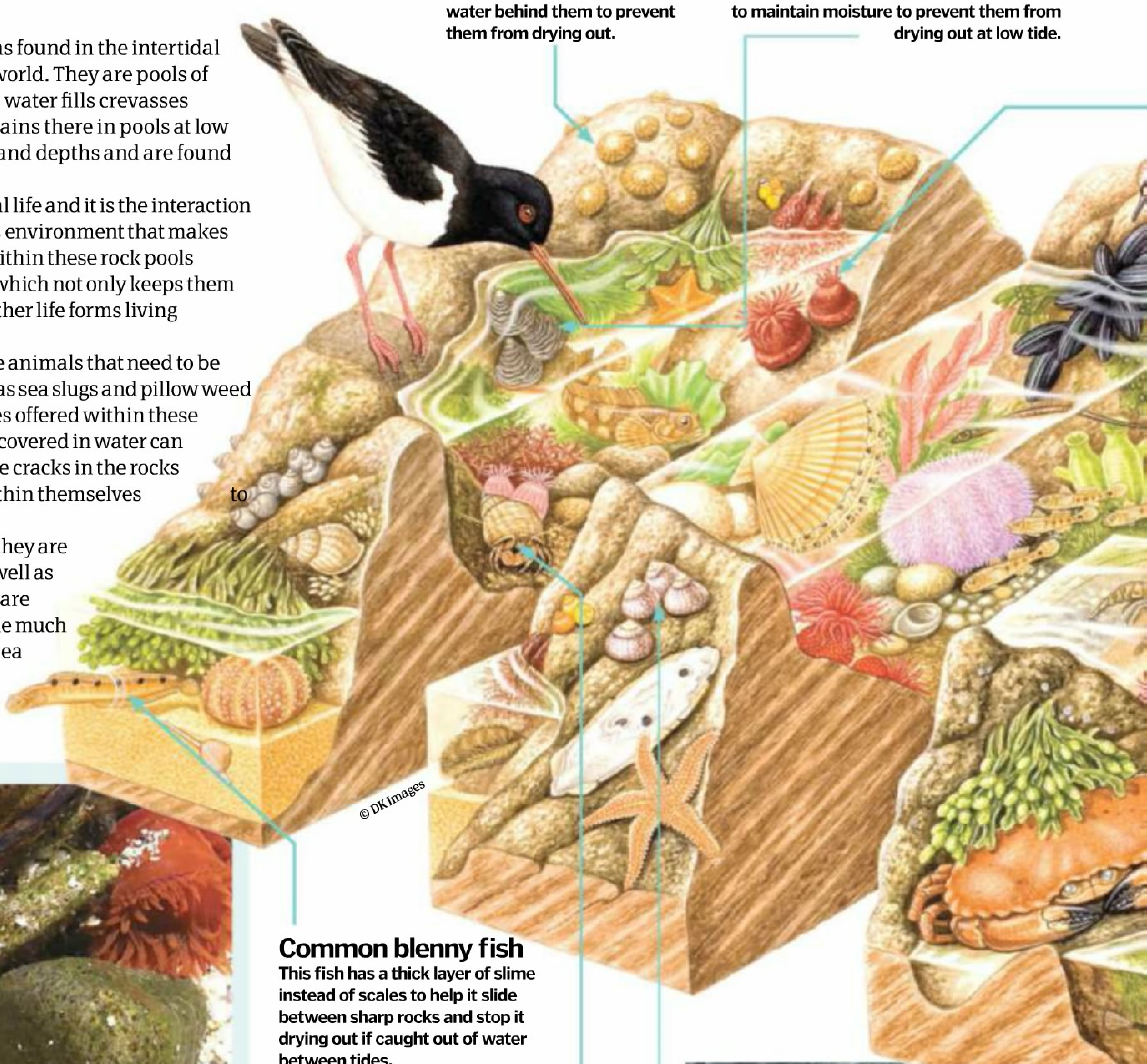
Rock pools are coastline ecosystems found in the intertidal zone of many beaches around the world. They are pools of water found on rocky shores where water fills crevasses during high tide and the water remains there in pools at low tide. These pools can be various shapes, sizes, and depths and are found both high and low on the shore.

Rock pools are teeming with plant and animal life and it is the interaction between all of these and their adaptation to this environment that makes each pool an ecosystem of its own. The plants within these rock pools perform the crucial process of photosynthesis, which not only keeps them alive but also produces oxygen needed for the other life forms living alongside them.

The deeper pools can provide homes for those animals that need to be constantly submerged. Fragile organisms such as sea slugs and pillow weed also take advantage of the shelter from the waves offered within these pools. Animals that don't need to be constantly covered in water can often be found higher up the pools. Many use the cracks in the rocks as shelter and are able to store enough water within themselves to survive between tides.

Conditions within the pools can be varied as they are affected by the incoming and outgoing tides as well as their position on shore. Those high on the shore are replenished less often and as a result can provide much tougher environments while those close to the sea can sometimes remain totally submerged. In between these extremes, pools are uncovered and submerged with the twice-daily tides.

Life forms of a rock pool



Limpets
When the tide is out, limpets fit tightly to the rock, trapping a little water behind them to prevent them from drying out.

Marine snails
These snails hide underneath the seaweed to protect themselves from predators and to maintain moisture to prevent them from drying out at low tide.

Common blenny fish
This fish has a thick layer of slime instead of scales to help it slide between sharp rocks and stop it drying out if caught out of water between tides.

Hermit crabs
These crabs protect their soft bodies from predators in this tough environment by climbing inside the discarded shells of other creatures and using them as their own.

Goose barnacles
These are able to live in rock pools because they can easily live without water during times of low tide as they do not have gills that get oxygen from the water.

© DK Images

There's plenty in these ecosystems to entertain children

The harsh environments mean only adapted species can survive

© Jim Champion

Hidden dangers

Rock pools can be harsh living environments with constant changes in temperature and salinity, and rain adding fresh water to the salt water. High pools have to wait longer for replenishment and shallow pools with less water are more prone to extremes. Conditions in the splash zone can also be difficult as during low tide they are exposed to the elements and salt spray. Small pools may also not provide enough oxygen for larger fish.

Head to Head ECOSYSTEMS

© NASA

1. Great Barrier Reef

Stretching out over more than 344,400 square kilometres, this coral reef ecosystem resides off the coast of Australia.

2. Amazon Rainforest

Covering an area greater than 6.7 million square kilometres this South American ecosystem is diverse with plants, animals and the river.

3. Sahara

The largest desert in the world, this African ecosystem is over 8.6 million kilometres squared. It's almost as large as the whole of Europe.

DID YOU KNOW? All the participants in the ancient Olympics, for the first several centuries of the competition, were aristocrats

Beadlet anemones live on the upper level of rock pools

© M Lück06

Beadlet anemones

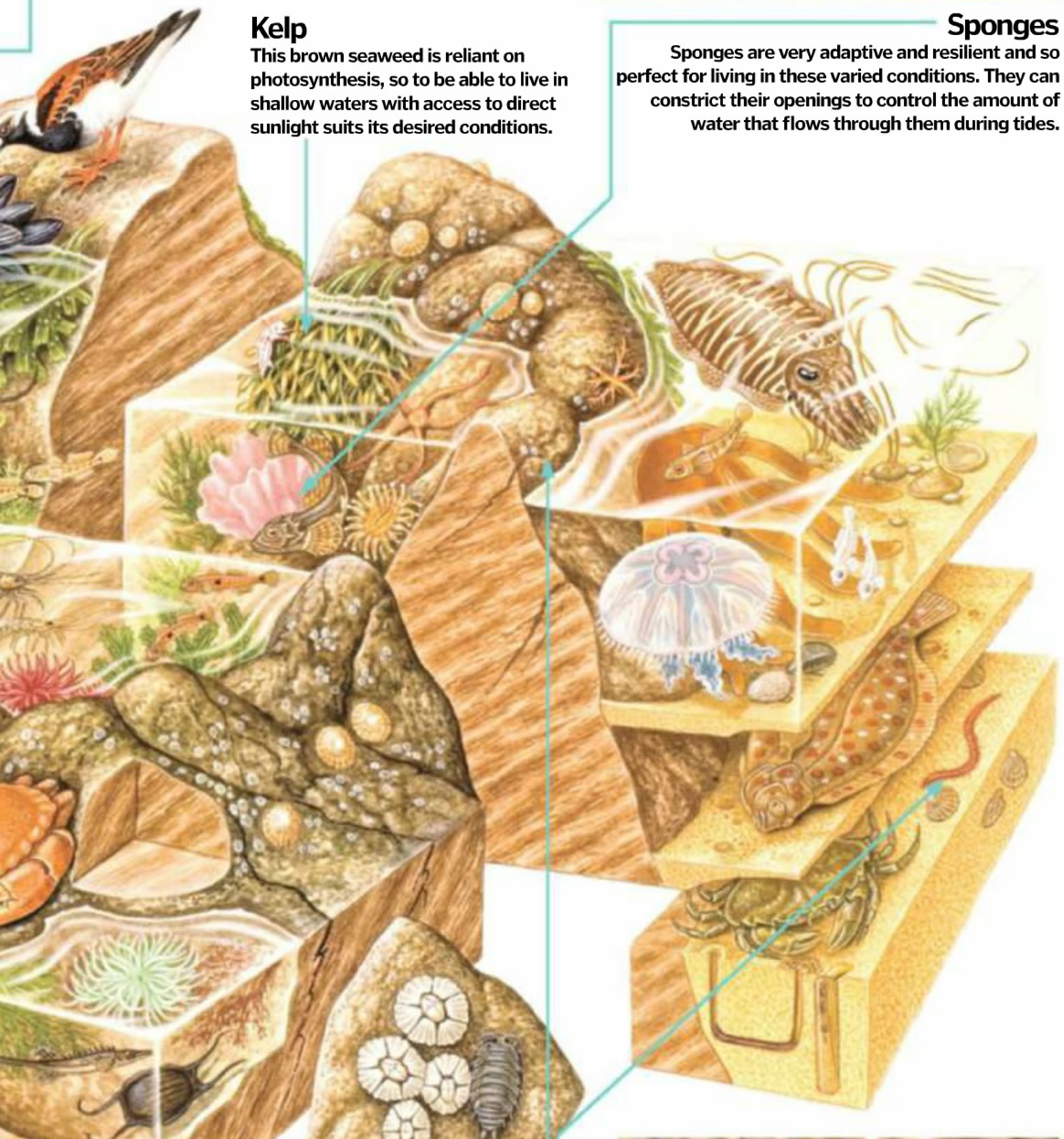
These live on the upper levels of the pool and while the tide is out, they retain moisture by keeping their mouths closed and tentacles tucked in.

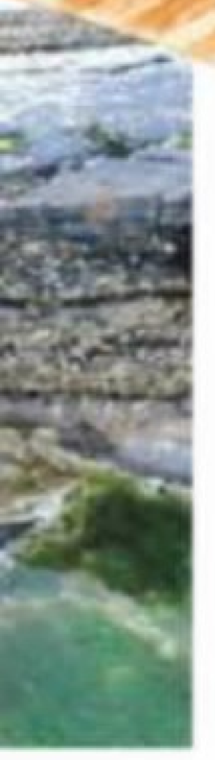
Kelp

This brown seaweed is reliant on photosynthesis, so to be able to live in shallow waters with access to direct sunlight suits its desired conditions.

Sponges

Sponges are very adaptive and resilient and so perfect for living in these varied conditions. They can constrict their openings to control the amount of water that flows through them during tides.





Sandhoppers

Sandhoppers move mainly at night and do not like to be in the hot sun that often shines directly on to rock pools, therefore they can bury themselves in sand during the day.

Worm pipefish

This fish is thin, brown and worm-like and can disguise itself in rock pools as a strand of seaweed, to protect itself from predators.

Sandhoppers move mainly at night to avoid the sunlight

© Arnold Paul06

Rock pool conditions

The constant tidal changes affect both temperature and salinity within the pools. Shallow pools evaporate with direct sunlight, increasing salinity in the remaining water. However, when rain falls it tops them up with fresh water, lowering the salinity. Higher pools are most affected as they are refreshed less often.

Temperature is also fairly varied when the tide is out, with air temperature and sunlight the main contributing factors. Although direct sunlight increases temperature, the rock surrounding the water stops it from getting too hot. A variation of 10-11°C is usually the maximum daily fluctuation. Both temperature and salinity within pools are affected by the size and shape of the pools, with the smaller shallower pools' conditions more quickly altered.

© Guttorm Flatabo

Supralittoral

At the top of the diagram below you can see the splash zone, also known as the supralittoral zone. It is at the top of the rock pool and is rarely submerged; rather it is sprayed with salt water. With this, as well as exposure to the wind, the life in this zone tends to hide and shelter in the gaps between the rocks. Exposed rocks are home to the small periwinkle (left).

© Mila Zinkova

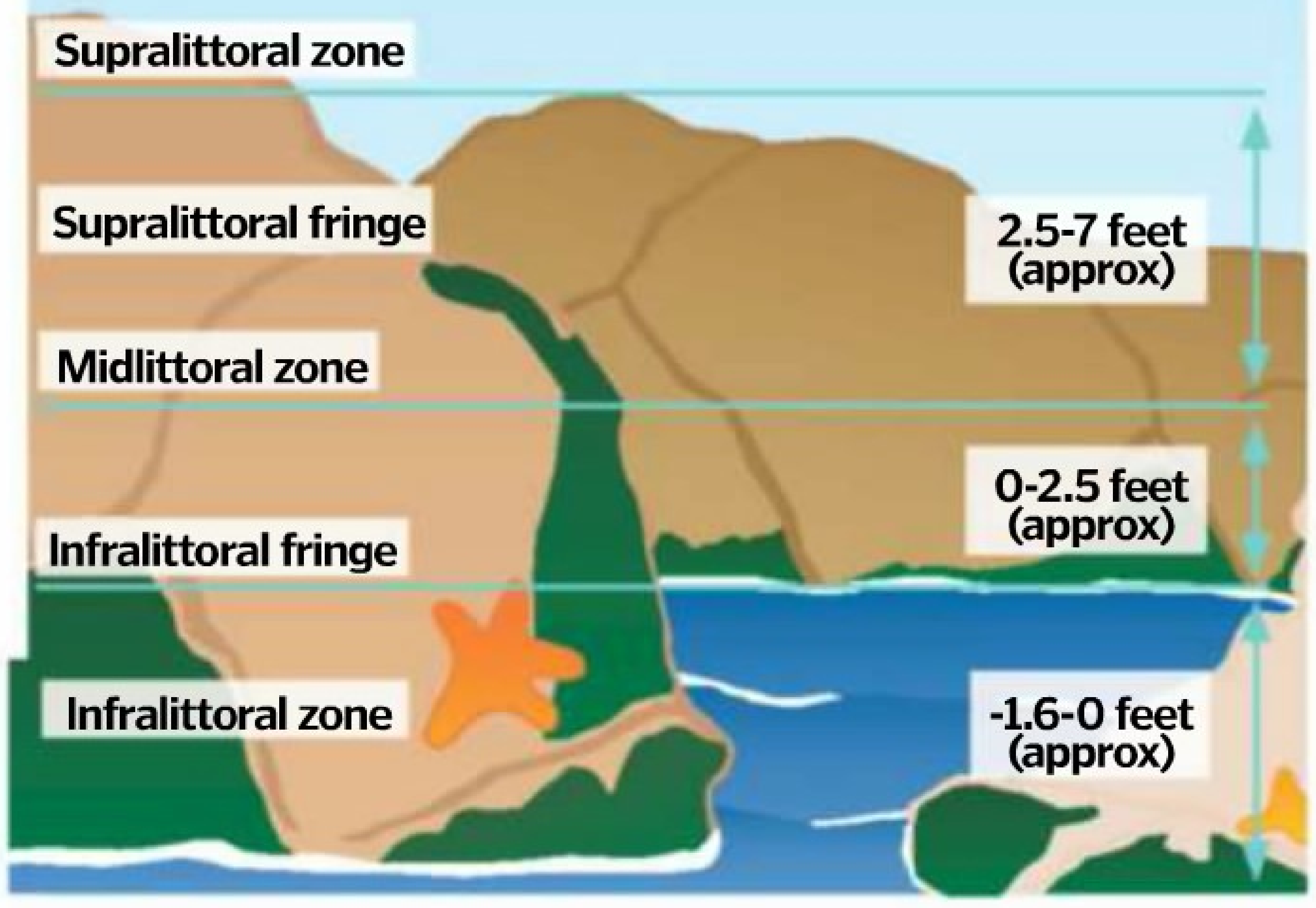
Midlittoral

Beneath the supralittoral zone lies the midlittoral zone, which is ruled by the tide as it is covered and uncovered twice each day. The organisms that live here have adapted to cope with the lack of moisture in these conditions. Anemones (left) and mussels, for example, close up when the tide is out to retain moisture, then reopen to feed when it returns.

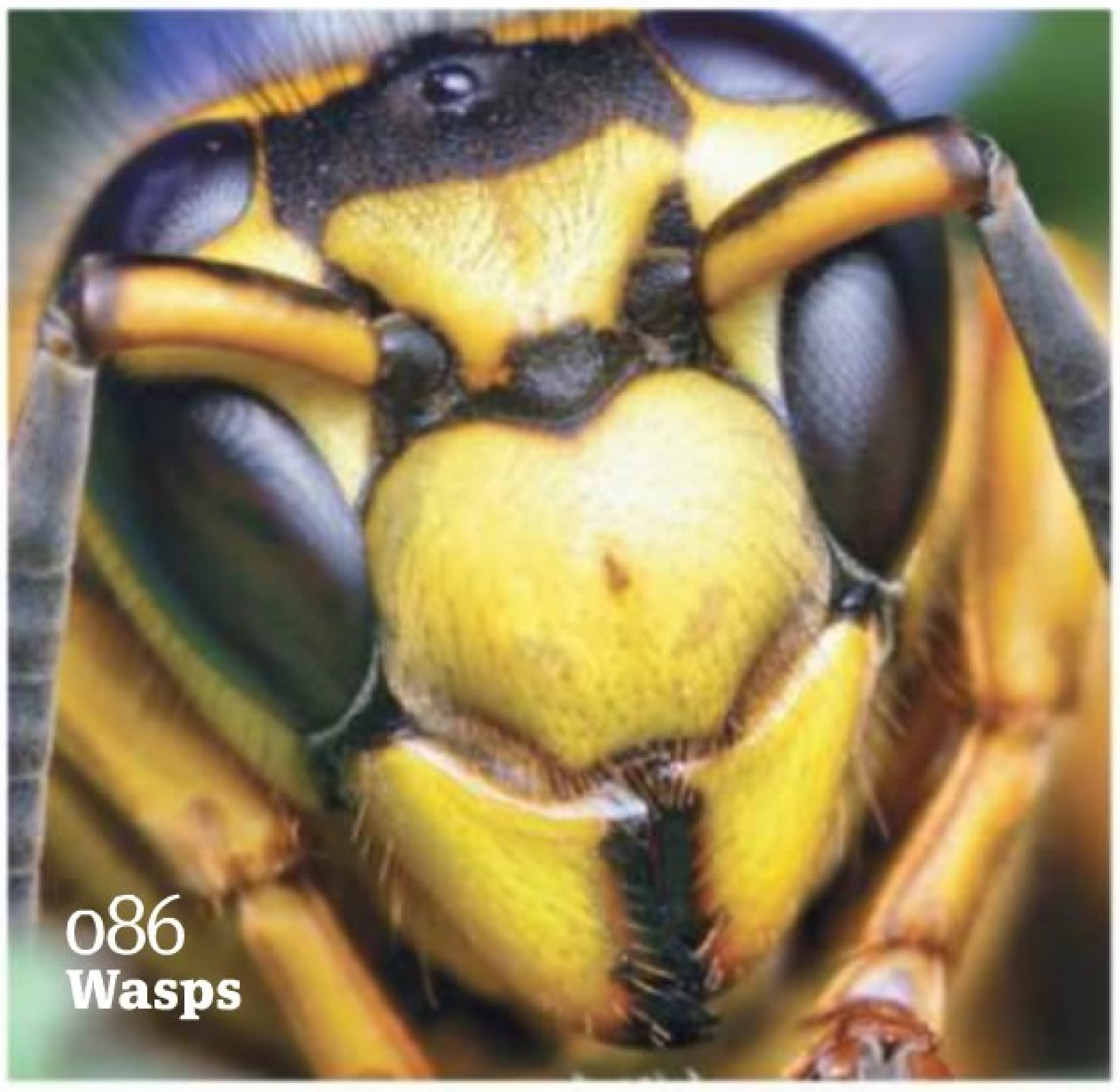
Infralittoral

At the bottom of the rock pool is the infralittoral zone, which is rarely exposed – only in the very lowest of tides. This area is a good home for many organisms as they don't need to be as adaptive and the conditions aren't so harsh. It is home to life forms that cannot tolerate much exposure to sunlight or can't live without water, like the black-eyed goby (left).

Rock pool zonation



SPIDERS & INSECTS


086
Wasps

Ladybirds
088

© SPL

074
Exoskeletons

073
Grasshoppers

Scorpions
076

Spiders & insects

066 Micro monsters
Life under the microscope

070 Termites
Industrial-scale builders

071 Ants
Class-based colonies

072 Slugs & snails
Slimy garden munchers

072 Ticks
Tiny bloodsuckers

073 Grasshoppers
The jumpers in the fields

073 Moulting
Sloughing off the old life

074 Exoskeletons
Armour-plated animals

076 Scorpions
King of the stingers

078 Spiders
Eight-legged stalkers

080 Black widows
Hungry mothers

081 Spider webs
The house of silk

082 Tardigrades
Indestructible bugs

082 Water striders
Light on their feet

082 Dung beetles
One person's waste…

083 Compound eyes
The ultimate wide-angle lens

084 Honeybees
Dancing harvesters

085 Beehives
The honey maker

086 Wasp nests
Built by a queen

086 Wasp stings
Alarming tails

087 Mosquitos
Determined bloodsuckers

087 Fireflies
Lamp-swinging beetles

087 Moths
The light's fantastic

088 Ladybirds
Red-caped heroes

089 Dragonflies
Complete six-way propulsion

089 Butterfly metamorphosis
The hungry caterpillar

090 Giant insects
The world's biggest bugs

078
Spiders

083
Compound eyes

© Muhammad Mahdi Karim

070
Termites

© Fir0002/Flagstaffotos

084
Honeybees

080
Black widows

A velvet mite, what a site!

Micro monsters

Largely invisible to all but the most powerful microscopes, a menagerie of micro monsters live all about us – in our homes, on our food and even on human beings themselves

5 TOP FACTS MICRO MONSTERS

Vampiric
1 A fully grown head louse bites the human scalp between three to five times each day in order to drink the blood, sucking it directly into their digestive tract.

Host
2 A louse's eggs, from which the next generation emerges, are actually attached to its host's hair directly, allowing for an instant transition post-hatch.

Bee-gone
3 One specific variant of mite, Varroa destructor, lives on bees alone. It is an external parasitic mite and spreads viruses that can kill entire colonies.

Sneezy
4 Mites are the cause of numerous allergies, including hay fever, eczema and asthma. They exacerbate these most in warm, humid conditions.

Mighty
5 The tropical variant of mite, Archegozetes longisetosus, is one of the strongest animals on Earth, capable of lifting 1,182 times its own weight.

DID YOU KNOW? Scientists have identified over 48,000 species of mites, only five per cent of their estimated total

> "This is the reality of the unseen world operating all around us, a massive multitude of micro beasties feeding off carbon in all its forms"

Mites, lice, silverfish and termites – but a small selection of the microscopic creatures living in your home and, if you refer to bath time as an annual event, on you as well. This is the reality of the unseen world operating all around us, a massive multitude of micro beasties feeding off carbon in all its forms, be that a human hair, a piece of cheese, inside your skirting board or on each other; it is a cut-throat world of silent, unseen organisms that have inhabited our planet for over the last 400 million years. Well, considering they have been alive so long, maybe it is we who inhabit their planet, as not only have they existed far longer than modern humans, but they are more numerous too, with their species numbering hundreds of thousands and their diversity unparalleled.

However, now with the usage of powerful scanning electron microscopes (SEM), scientists are prising open the doors to this unseen world and watching as beasts akin to the creations of the most fevered dreams take form in their millions, marching over a world that has long-since been their home, one in which they have adapted and evolved furiously and efficiently to exploit. Indeed, their appearance – grotesque by human standards – actually betrays their success as species: minimal, streamlined, sense-orientated and above all efficient, it is secondary to function, and gives us a valuable insight into the development and evolution of carbon-based life forms. After all, what use is it looking pretty if you cannot defend yourself from predators, scavenge food, and live in the most demanding of environments?

So strap yourself in as we give you a tour of some of the more common micro monsters living in your own home, as while they aren't for the squeamish, they are fascinating and intriguing life forms nonetheless which tell us much about organisms and evolution.

No it's not an image from *Starship Troopers...*

Meal mite

FOUND: Kitchen
The Meal species of mite is a common pest of granaries, mills and kitchens, feeding particularly on grains and cereals. It reproduces rapidly under good conditions, while under unfavourable conditions it forms a resting stage in which it can survive for over two years.

Cheese mite

FOUND: Food
Cheese mites infest cheese and other foods, and are usually seen as pests, causing spoilage and asthma in people breathing contaminated air. Some cheeses however, such as Mimolette, are deliberately infected with certain mites to create the correct flavour.

Dust mite

FOUND: Everywhere
Millions of dust mites inhabit homes, feeding on shedded skin cells. They mainly live in furniture, and are usually harmless. However, their excrement and dead bodies may cause allergic reactions in susceptible people.

Mites

One of the oldest forms of micro monster inhabiting your house, the mite is among the most diverse and successful invertebrates on Earth

48,200 species have already been identified and scientists postulate that this figure is only five per cent of the total number of mites on Earth. They are strong (for their size), durable and – most importantly – highly adaptable to change, evolving quickly to exploit the different environments presented to them over millions of years. In fact they have proved so good at adapting to Earth's changing environment that mites – or more accurately, their sub-class Acari – have lived on Earth since the early Devonian period (416-359 million years ago), inhabiting the warmest and coldest climates and a vast array of living creatures. This evolutionary adaptability has granted mites almost unparalleled diversity and now, with the advent of the electron microscope, their numbers and types are visible for the first time.

Take the common house dust mite (Dermatophagoides pteronyssinus) from the pyroglyphidae family. This variant of mite dwells in human residences – including, as probability suggests, your home – and feeds entirely on organic detritus such as flakes of shedded human skin, flourishing in the stable environment and on a perpetual food supply. The dust mite is tiny and unseen, with a size of roughly 420 micrometers in length and 320 micrometers in height, highly reproductive – a female mite will lay 60 to 100 eggs in the last five weeks of her life – and impervious to all temperatures between 0°C and 60°C.

In essence, the dust mite is perfectly suited for life on Earth now, with the numbers of humans and houses in suitable climates (count yourself immune then in you live in Antarctica) in abundance. The ancestor that the common dust mite once shared evolved to take advantage of the rise of mammals (especially those which emerged from the nomadic tribal groups to set up permanent residences) and did so extraordinarily quickly. For while modern humans have only been around for 125,000 years, the Acari sub-class of mites has been around for over 400 million. This efficiency and adaptability is common in many micro monsters, as we will see over the page.

Main image and 3 x mites pictures © Science Photo Library

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SEM

The micro monster images contained within these pages come courtesy of scanning electron microscopes (SEM), which without we would not be able to observe. Electron microscopes produce electronically magnified images of specimens by utilising a particle beam of electrons. These electrons interact with the target's atoms and produce signals that contain information about the specimen's topography, composition and chemical properties. The electron microscope – due to electrons having wavelengths roughly 100,000 times shorter than protons (visible light) – allows for a magnification of up to 1,000,000x, which is vastly greater than the most powerful optical telescopes, which are limited to just 2,000x magnification.

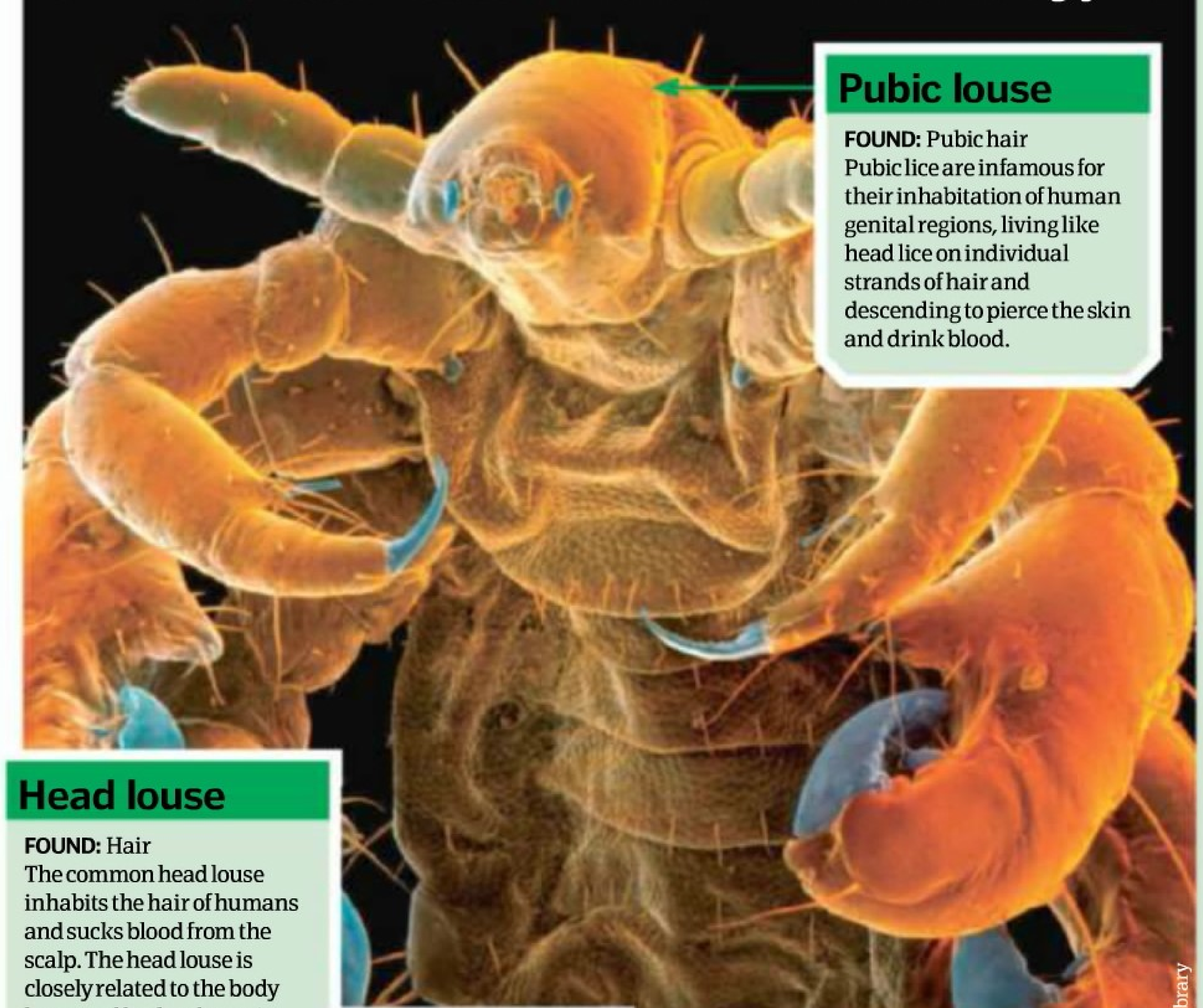
Lice

Parasitic wingless insects, lice can be found on the majority of birds and mammals… including you

Lice are another species of micro monster that are close to home – literally – as not only are they found in your home but they live on humans themselves. In fact, lice cannot exist without a host (an obligate parasite), so it is rare to find them on non-organic matter. Most lice are scavengers by nature, feeding off the skin, blood and detritus found in and on the host's body, and often dwell in hair. There are over 3,000 species of louse (although only three are found on humans) and they live exclusively on avian and mammalian orders.

Head lice live on individual strands of human hair, clinging to them with crab-like limbs and measure two to three millimetres in length. To feed, the lice descend down to the scalp where they consume dead skin and drink blood – a process that involves the louse biting the scalp, injecting its saliva to clot the blood, and then extracting it into its body. When reproducing, female lice produce eggs that they attach to the strand of hair that they are clinging to with their sticky saliva. This means that when the egg hatches – young lice are called nymphs – they can move directly onto the same strand as their parent.

Scientists have discovered from analysing DNA evidence from modern humans' ancestors that lice spread to humans approximately 2,000 years ago from gorillas, who still share a susceptibility to lice.



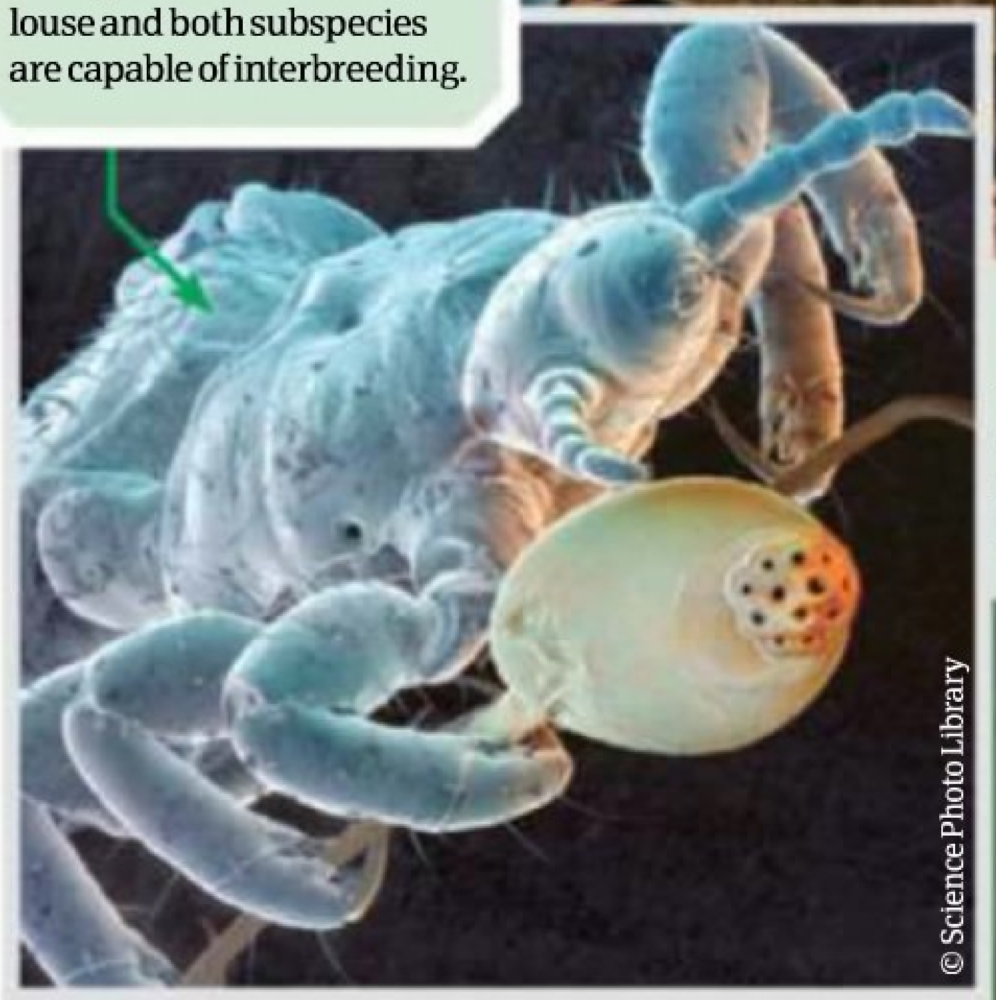
Pubic louse

FOUND: Pubic hair
Pubic lice are infamous for their inhabitation of human genital regions, living like head lice on individual strands of hair and descending to pierce the skin and drink blood.

© Science Photo Library

Head louse

FOUND: Hair
The common head louse inhabits the hair of humans and sucks blood from the scalp. The head louse is closely related to the body louse and both subspecies are capable of interbreeding.



© Science Photo Library

Louse eggs

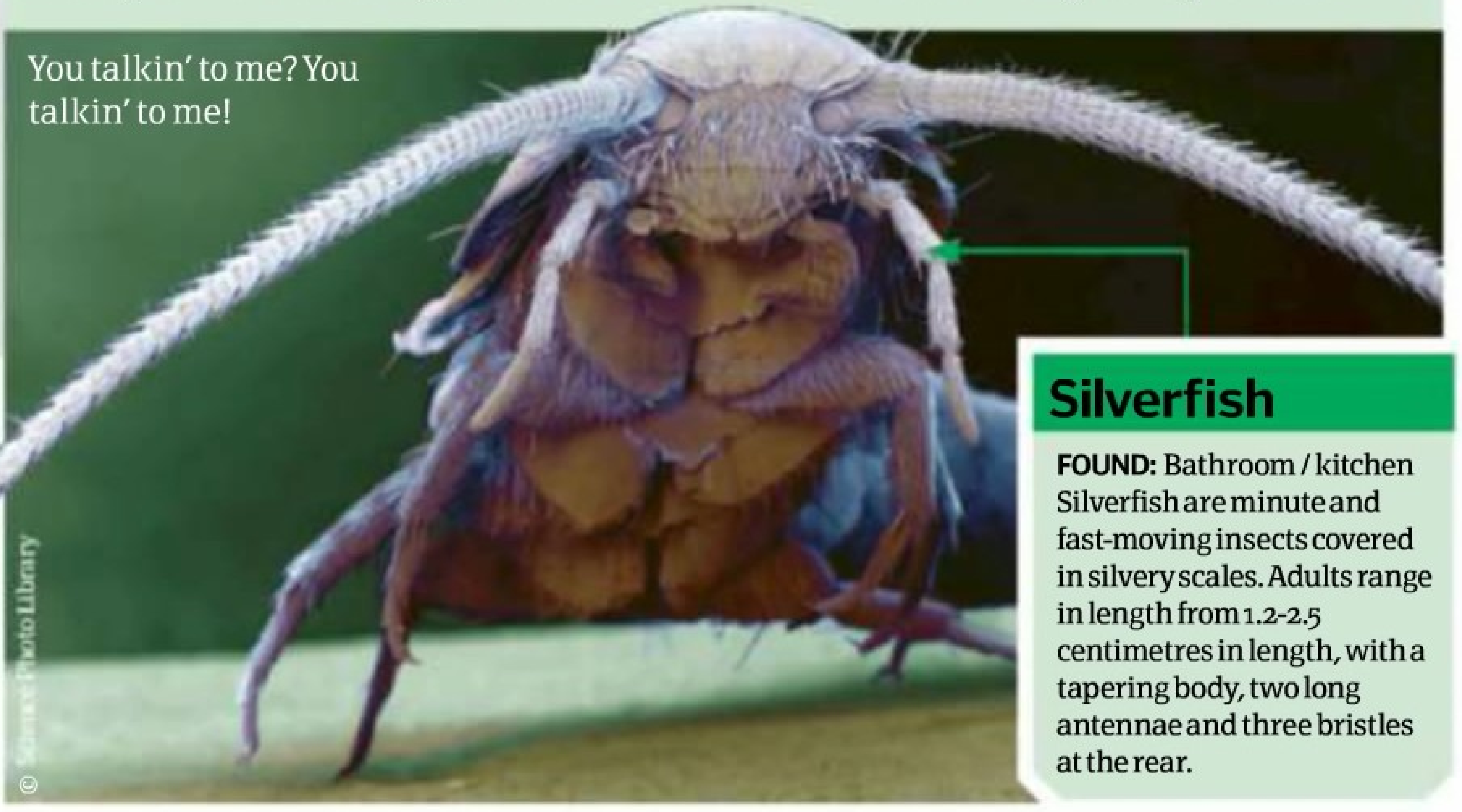
A louse with its egg – it has been glued to a hair strand. The egg has a perforated lid, which is removed by the emerging nymph. A female louse lays between 80-100 eggs in a lifetime.

Silverfish

Nocturnal, razor-fast, silent: introducing the fastest micro monster your house has ever seen

Another ancient species that has inhabited Earth for millions of years, the common household silverfish (Lepisma saccharina) is a tiny but visible insect in the Thysanura order. Often found in areas of high humidity – such as bathrooms – silverfish are elongated, flattened insects that measure between 1.2-2.5cm in length. They are not parasitic creatures, unlike mites and lice, consuming matter that is high in starches and sugars such as: cotton, paper, carpet, synthetic fabric and leather. Their speed comes courtesy of six legs and streamlined physical construction, allowing them to scuttle quickly and dynamically with minimal residence.

As with mites and lice, the silverfish is aesthetically unpleasant, but as with its fellow microscopic brethren it doesn't need to be and it is another good example of evolutionary priority. Despite the majority of its variants fitted with compound eyes, the silverfish technically doesn't require them – indeed, some varieties have none at all – as their finely tuned and large antennas and triple-arrayed cerci (largely rear-mounted appendages used as sensory organs) give it excellent positional awareness, and thanks to its monumental speed considering its size, it is an almost predatorless species, with only certain centipedes and spiders capable of hunting it. Finally, the silverfish can live for up to a year without eating, greatly enhancing its ability to survive and reproduce.



You talkin' to me? You talkin' to me!

© Science Photo Library

Silverfish

FOUND: Bathroom / kitchen
Silverfish are minute and fast-moving insects covered in silvery scales. Adults range in length from 1.2-2.5 centimetres in length, with a tapering body, two long antennae and three bristles at the rear.

2 x termite pics (second bottom right p17) © Science Photo Library

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Head to Head
PARASITIC INSECTS

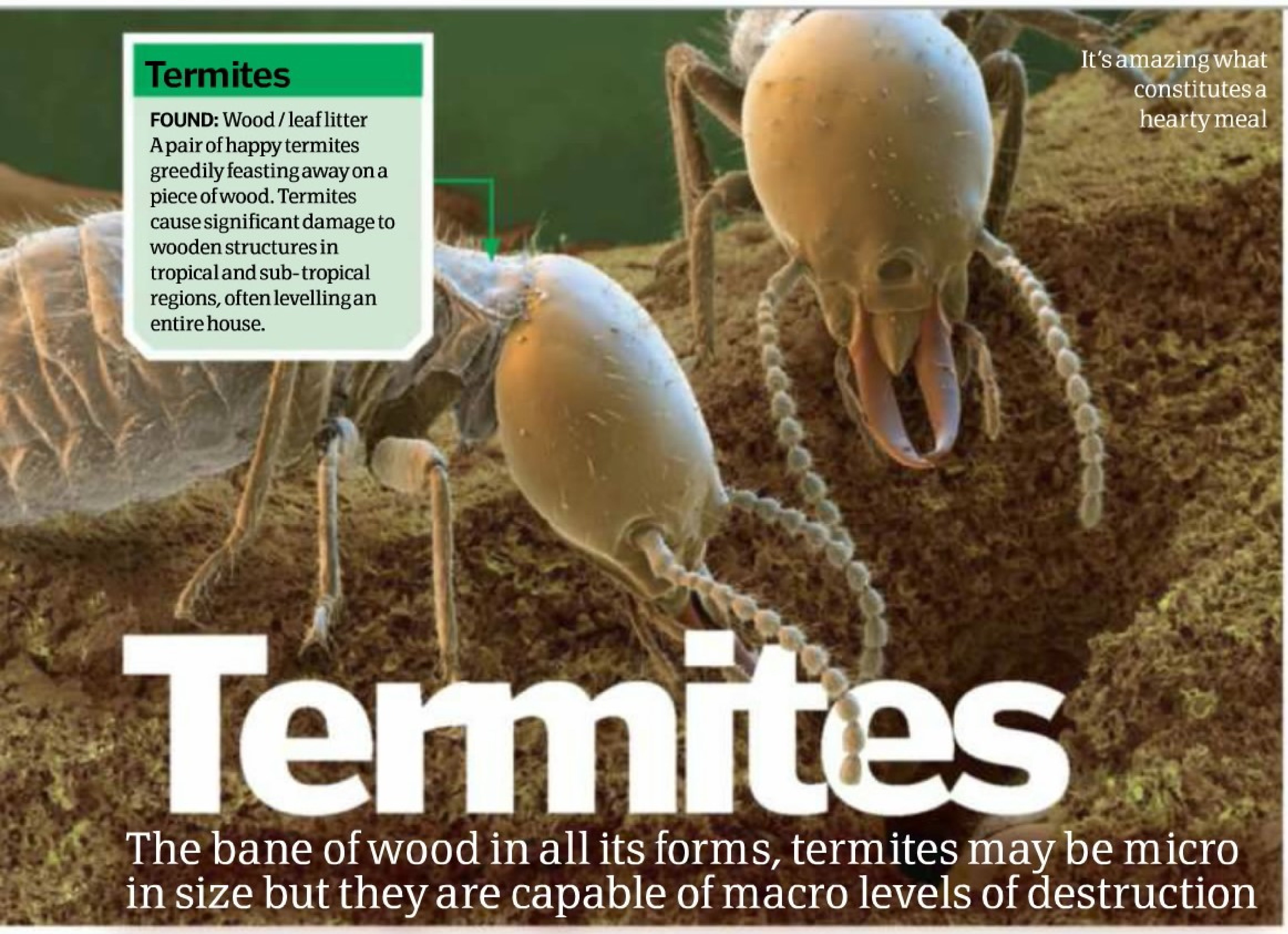
1. Louse
Found on mammals and birds, the louse clings to its host via individual strands of hair, descending three to four times a day to drink its blood.

2. Tapeworm
A worm that lives inside the digestive tract, the tapeworm absorbs nutrients through its skin from food consumed by its host as it is digested.

© Alvesgaspar

3. Mosquito
One of the most feared and prevalent parasites alive today, the mosquitoes suck the blood of their host and transmit various diseases including malaria.

DID YOU KNOW? *A species of ant, Globitermes sulphurous, protects its colony by exploding, trapping invaders in its sticky remains*



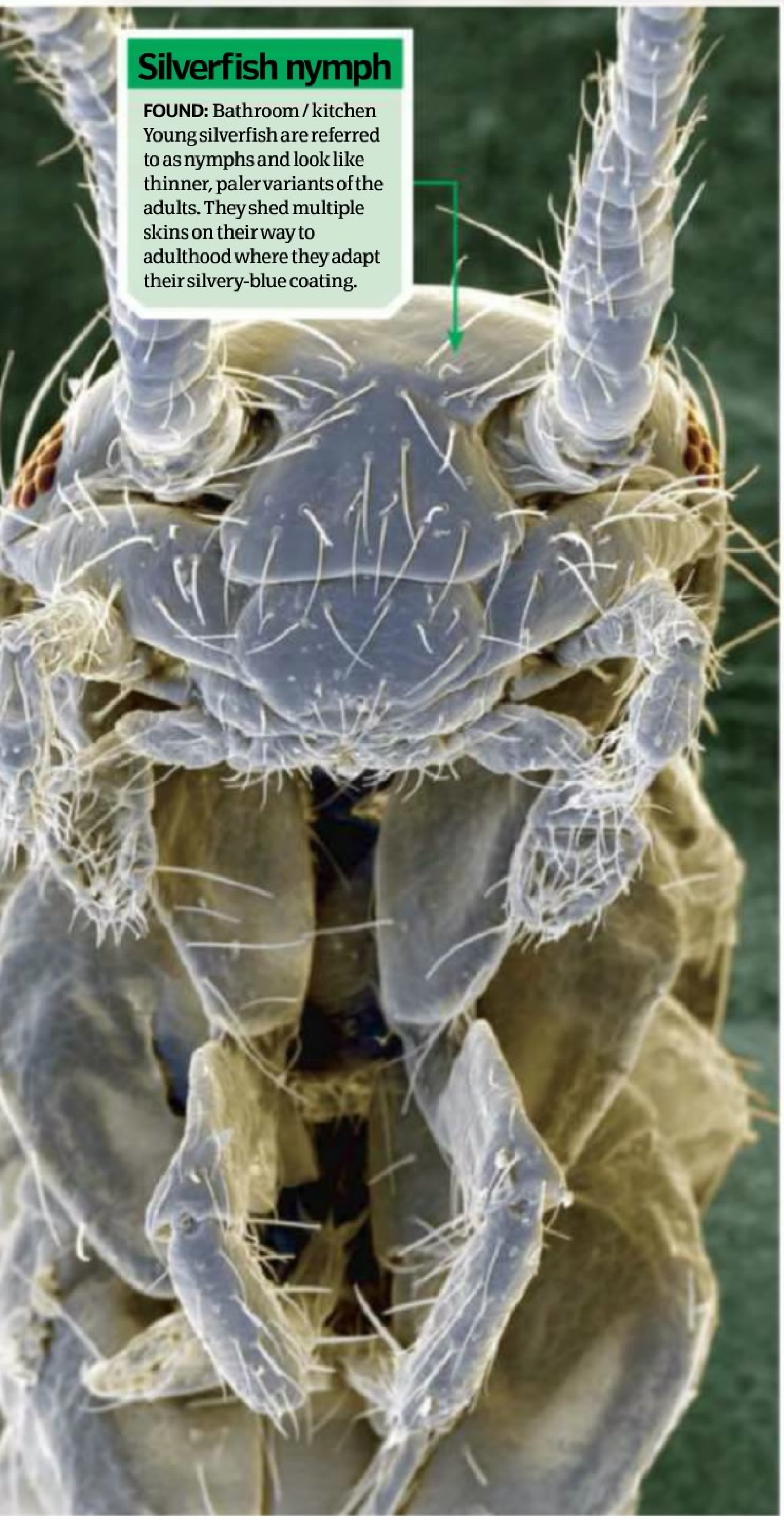
It's amazing what constitutes a hearty meal

Termites

FOUND: Wood / leaf litter
A pair of happy termites greedily feasting away on a piece of wood. Termites cause significant damage to wooden structures in tropical and sub-tropical regions, often levelling an entire house.

Termites

The bane of wood in all its forms, termites may be micro in size but they are capable of macro levels of destruction



Silverfish nymph

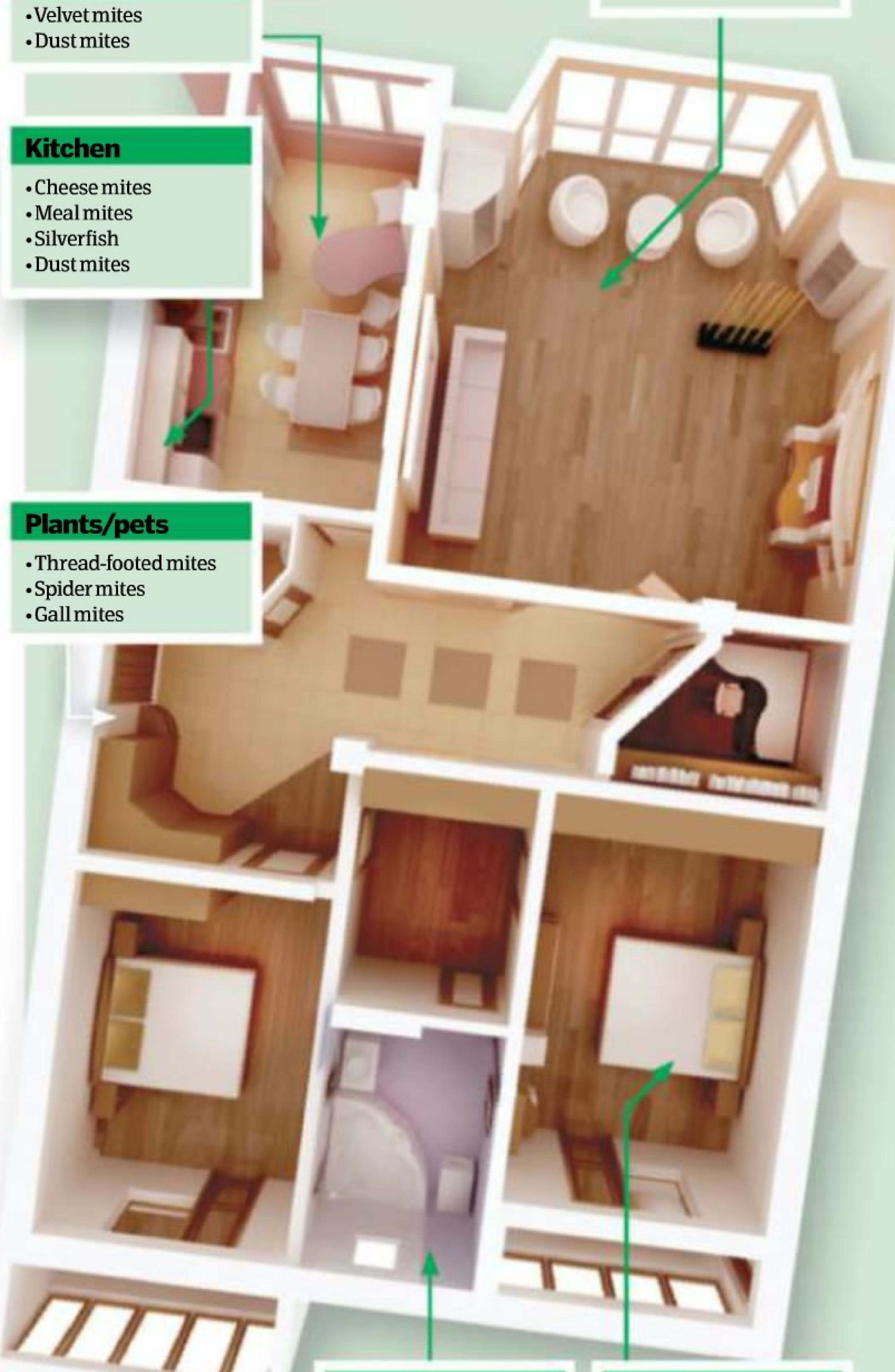
FOUND: Bathroom / kitchen
Young silverfish are referred to as nymphs and look like thinner, paler variants of the adults. They shed multiple skins on their way to adulthood where they adapt their silvery-blue coating.

While the other micro monsters featured here are potentially damaging to your health and belongings, the termite – a member of the Isoptera order – is neither a parasitic organism nor one that has a taste for your bookazine collection. Instead, they are major detritivores – organisms that feed by absorbing nutrients from detritus – that consume mainly dead plant material such as wood, leaf litter and soil. In nature this is a common behaviour and one that is invaluable to the ecosystem, contributing greatly to the effects of decomposition and the recycling of nutrients. However, when it is the wooden beams of a human home, this becomes more of a problem.

Termites – albeit in a slightly devolved ancestral form – have existed on Earth from the early cretaceous period (145 million years ago) and are reasoned by scientists to be close relatives of cockroaches and mantids. They are eusocial and, arguably, more highly evolved organisms however, living in decentralised, self-organised colonies of hundreds to millions of individuals – split into job roles such as reproductives, workers and soldiers – each guided by a swarm intelligence that allows them to exploit a range of food sources and environments that a singular termite would not be able to do so. Further, their nests or mounds are toughened structures and provide protection against predators.

Home invasion…

Where in our homes do these invaders reside?



Living room
- Dust mites
- Termites

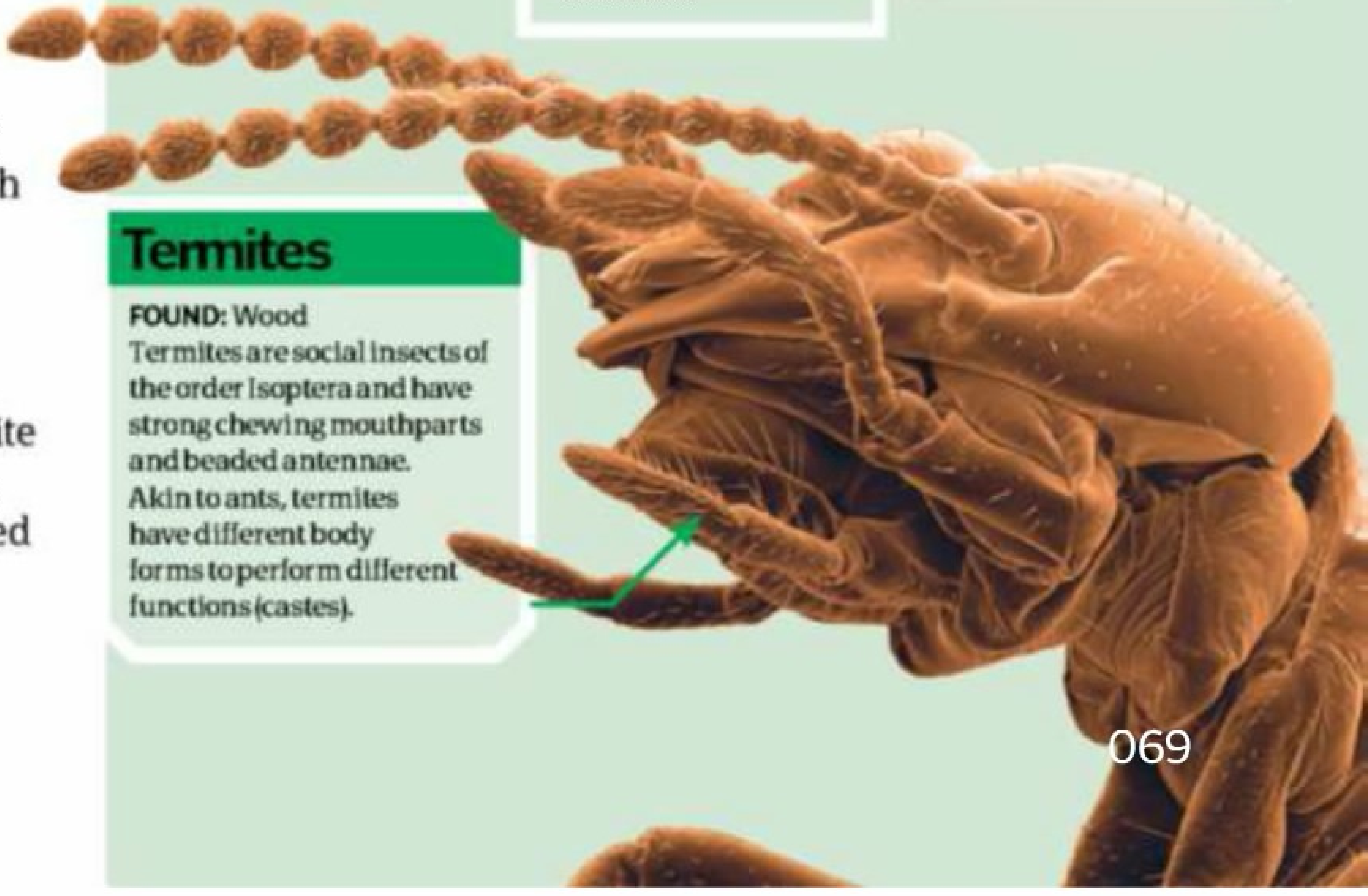
Carpets/curtains
- Velvet mites
- Dust mites

Kitchen
- Cheese mites
- Meal mites
- Silverfish
- Dust mites

Plants/pets
- Thread-footed mites
- Spider mites
- Gall mites

Bathroom/toilet
- Silverfish
- Silverfish nymphs
- Dust mites

Bedroom
- Bed bugs
- Dust mites



Termites

FOUND: Wood
Termites are social insects of the order Isoptera and have strong chewing mouthparts and beaded antennae. Akin to ants, termites have different body forms to perform different functions (castes).

Termite mounds

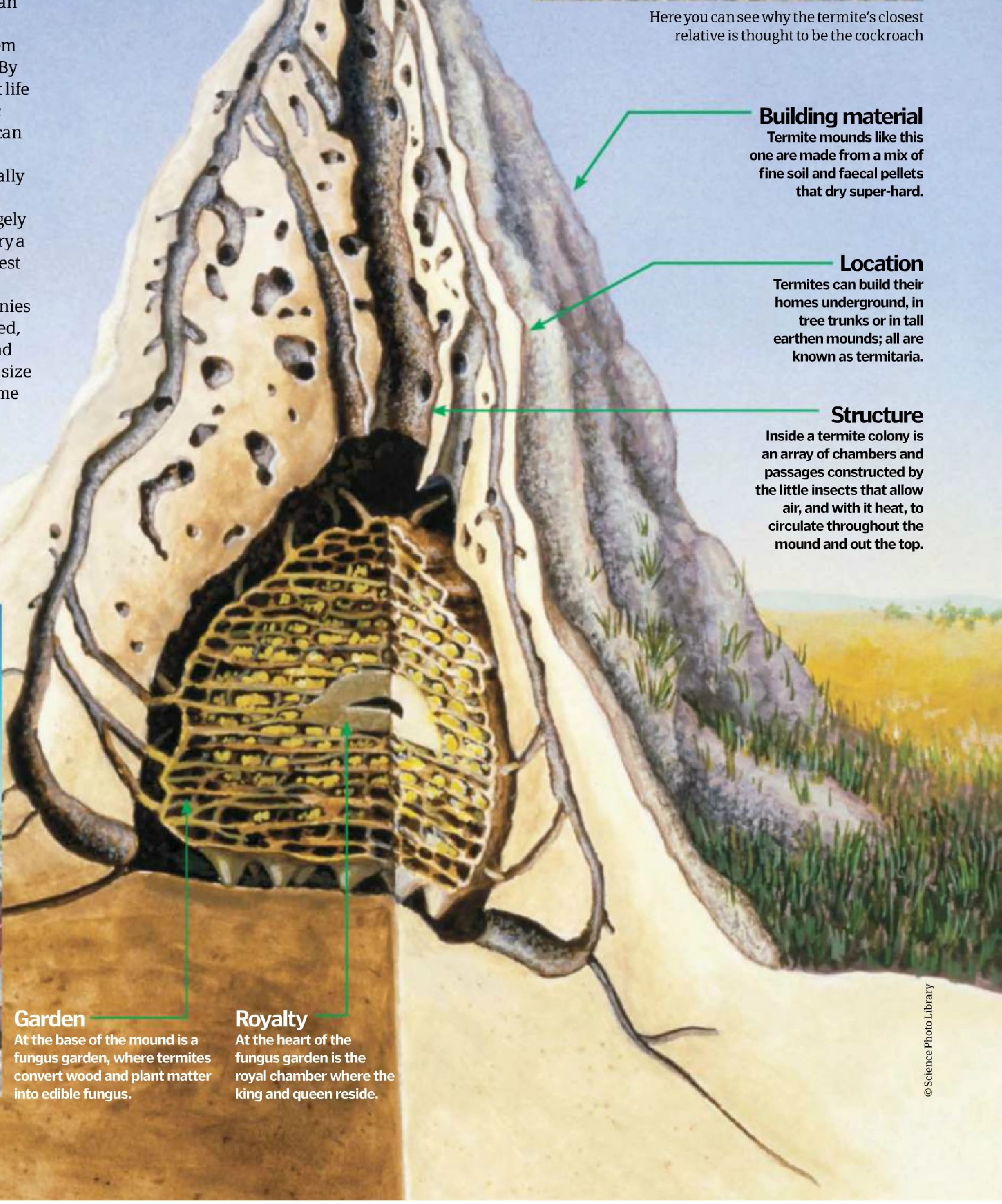
How does the wood-loving termite construct its home?

Termites are cellulose-eating insects that share many similarities with ants and bees, although, perhaps surprisingly, their closest relative is believed to be the cockroach. There are about 2,750 species of termite around the world, living in habitats as varied as tropical forests and the African savannah, through to the Pacific coast.

The eating habits of termites make them very important insects in an ecosystem. By consuming wooden structures and plant life they help convert dead trees into organic matter to trigger new life. However, this can cause problems, as they can eat through structural supports in buildings, eventually leading to their collapse.

Termites have evolved to eat wood largely because few other animals can; they carry a special bacteria that enables them to digest the tough cellulose fibres. This innate survival mechanism means termite colonies can be around for a very long time – indeed, some last up to 100 years. A termite mound (or termitarium) will reach its maximum size after four to five years, when it can be home to as many as 200,000 inhabitants.

Here you can see why the termite's closest relative is thought to be the cockroach



Building material
Termite mounds like this one are made from a mix of fine soil and faecal pellets that dry super-hard.

Location
Termites can build their homes underground, in tree trunks or in tall earthen mounds; all are known as termitaria.

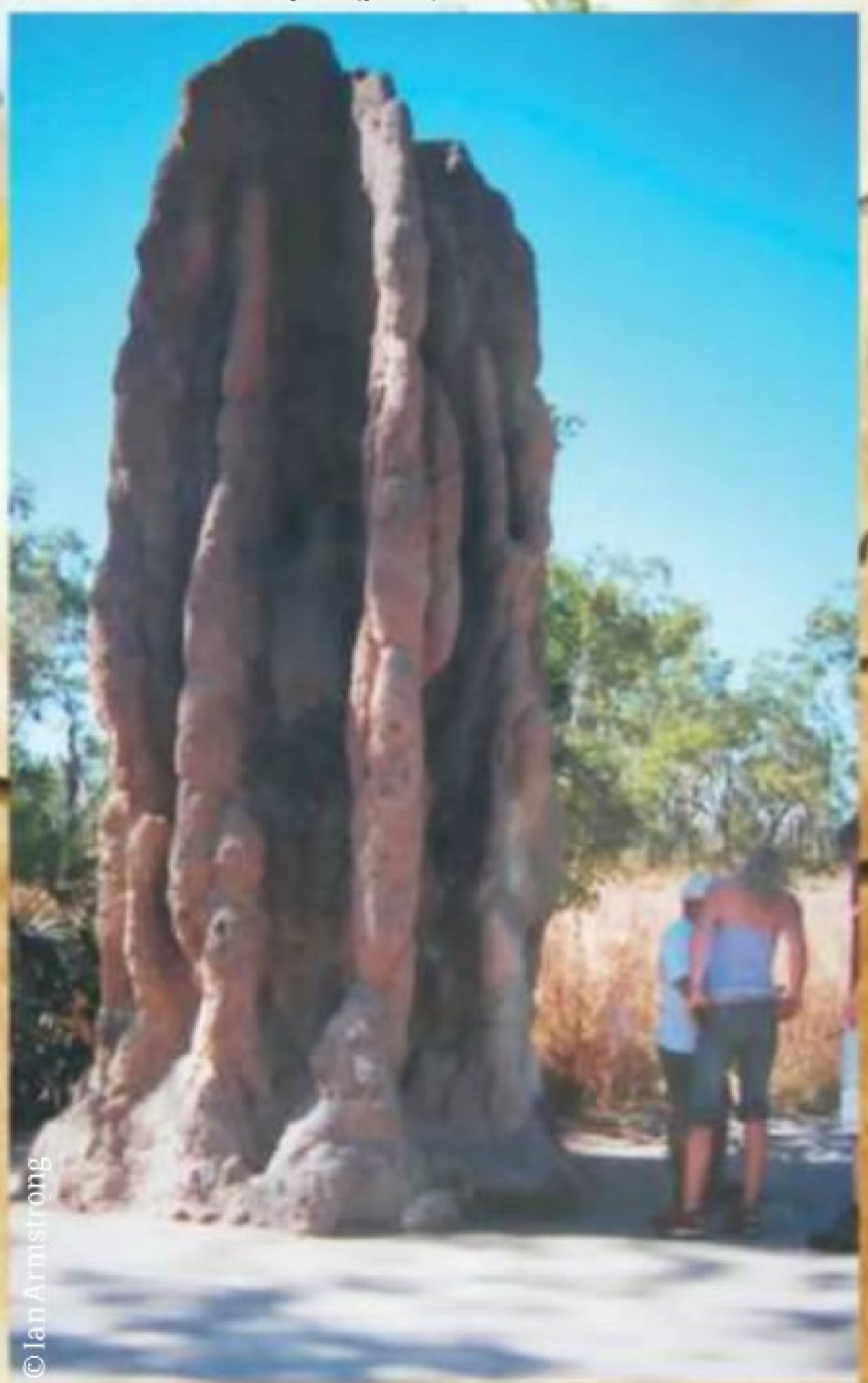
Structure
Inside a termite colony is an array of chambers and passages constructed by the little insects that allow air, and with it heat, to circulate throughout the mound and out the top.

Garden
At the base of the mound is a fungus garden, where termites convert wood and plant matter into edible fungus.

Royalty
At the heart of the fungus garden is the royal chamber where the king and queen reside.

© Science Photo Library

Some termite mounds can reach as tall as 9m (30ft)



© Ian Armstrong

5 TOP FACTS ANTS

Strength in numbers
1 There are approximately 12,000 known species of ant, composing around about 1.4 per cent of the world's total insect species.

Survival of the fittest
2 The family Formicidae are hardy little critters, who have existed on Earth for more than 140 million years, and aren't going anywhere soon!

Life expectancy
3 An ant Queen can live up to three years. Worker ants expect to live for a maximum of two, still impressive for an insect species.

Ant army
4 Eciton burchellii, a species of army ant, attack in formation with their swarm broadening to 15 yards, including up to 200,000 drones.

What's in a word?
5 In Japanese the word ant is intricately written by linking two separate characters, one meaning insect and the other meaning loyalty.

DID YOU KNOW? *Ants communicate primarily with pheromones, chemicals secreted and smelled or tasted by nest mates*

The inner workings of an ants' nest

The fascinating social structures of the mighty yet minuscule ant species

Ants, or the family Formicidae, are an interesting species of insect, which show a distinct and complex social infrastructure. Known as an ant colony, this social cycle is dependent on hierarchy, with the Queen starting the proceedings.

Once an ants' nest is successfully built, the Queen, or reproductive female, will take up residence after nuptial flight and shed her wings. One or a few male ants then inseminate her. This can take place in the nest, while stationary in the air or on low vegetation or the ground when food foraging. She then resides in an excavated chamber. Here she will lay her eggs, emerging as larvae, feeding them from regurgitate liquefied musculature, related to the wings.

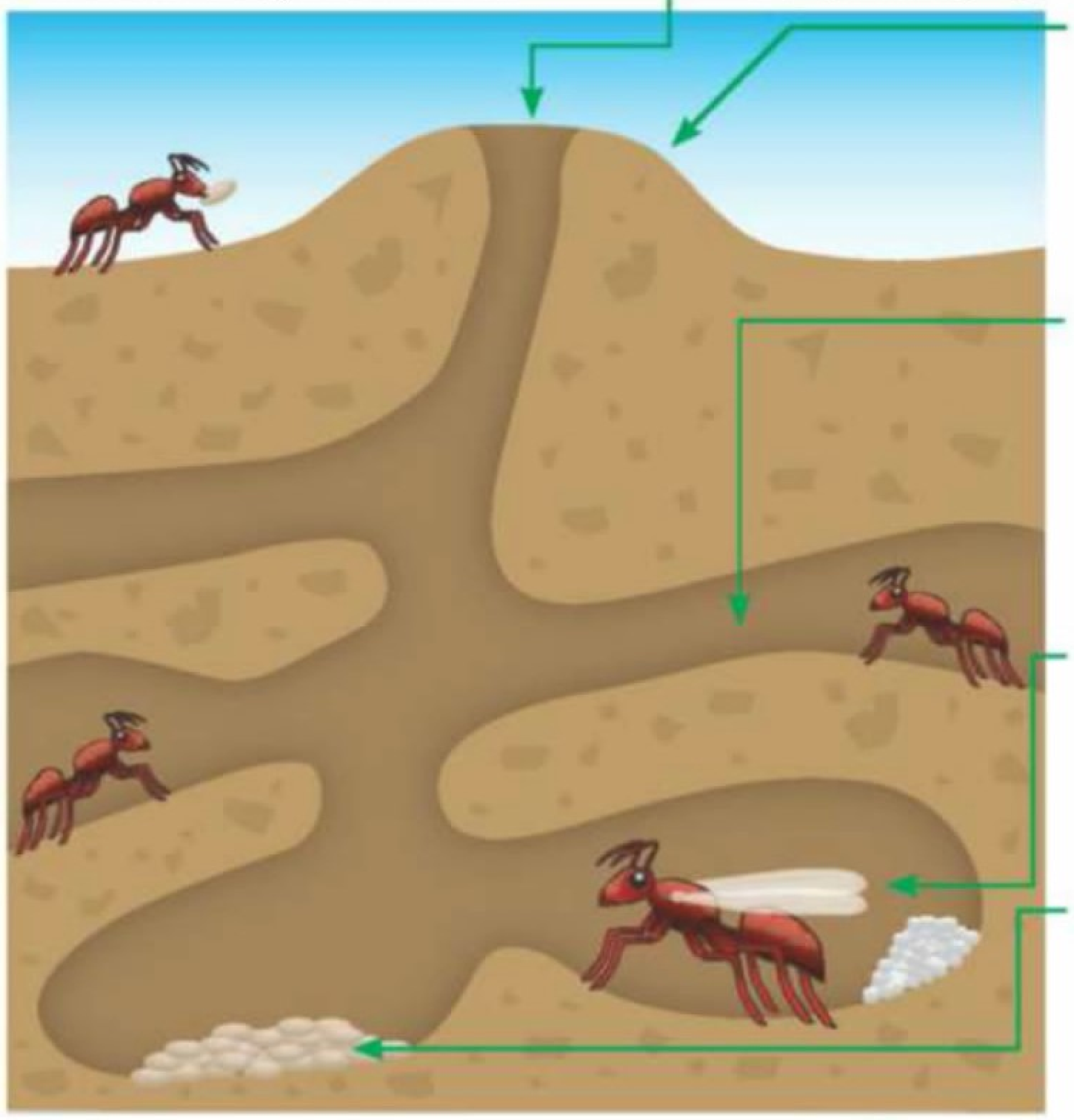
These initial numbers of worker ants are referred to as nanitics, spawning from eggs no bigger than 1mm in size. This life cycle – from larva, to pupa, to ant – often lasts from six to ten weeks. These are much smaller than subsequent workers, due to the ability of the Queen to only provide a limited amount of food, comparative to that which foraging workers later provide.

Initially the Queen is responsible for nest maintenance and defence, once larvae have reached maturity the Queen is only responsible for reproduction and populating the ant colony. It's now the ant workers turn to feed and sustain her majesty. This allows the colony to expand in population as well as territory and residence.

This of course takes a period of several years, after which the colony produces its first generation of sexuals, who will fly on the same day all at the same time, enhancing their chance to meet in the nuptial flight and to close the cycle. The reason behind this is also that the death of the Queen has devastating effects on a colony as ants seldom replace her, and have a survival expectancy of only several months after her demise.

Home sweet home

Ants' nests house complete colonies, so they have to be pretty big. The majority of this species decide to build intricate layouts underground, with some recorded at reaching six metres down.



Ant colonies are built and maintained by legions of worker ants. They carry tiny bits of dirt in their mandibles, depositing this near the exit of the colony. This forms what is know as an ant hill.

Each nest is an intricate labyrinth of tunnels and chambers that serve different functions and house different members of the ant colony. Each is interconnecting and has an opening that is connected with the surface.

The Queen ant understandably has the freedom of her own chamber. It's here, in this excavated area, that she will repopulate the colony, laying all her eggs.

Other chambers are used as nurseries tending to larvae. There are also food larders, stocking sustenance for the colony, and resting quarters for those hard-working ants.

Ant social types

Every ant knows its place, and the job of each one is just as vital as the next. But just what are the roles of the different ant classes?

NAME OF ANT:
Ant Queen
ROLE:
The Queen establishes but does not rule. Her role is to reproduce, and ensure the longevity of the colony.

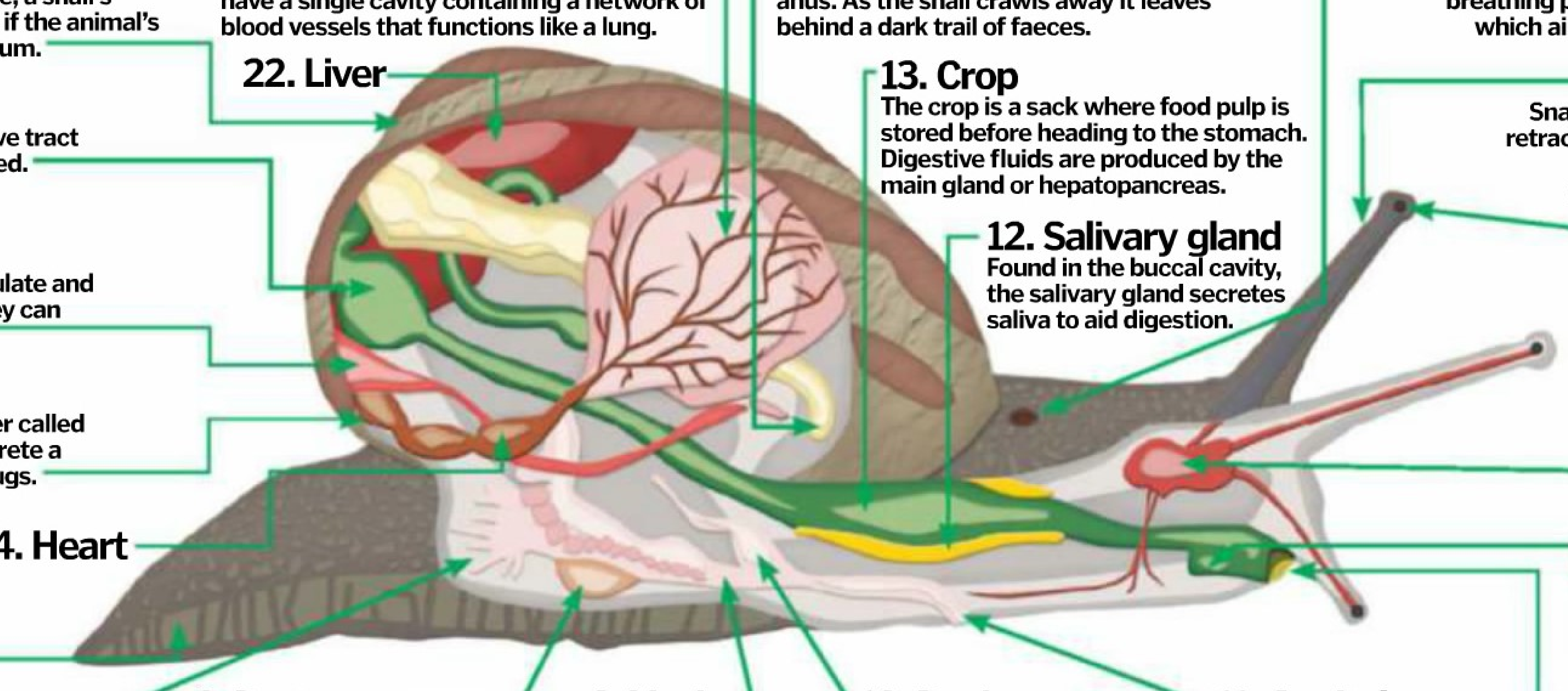
NAME OF ANT:
Worker
ROLE:
Perhaps the smallest, these ants care for the Queen and her young, build and repair the nest and forage for food.

NAME OF ANT:
Soldier
ROLE:
Significantly larger worker ants that are named as such due to their larger heads, and stronger mandibles.

NAME OF ANT:
Drones
ROLE:
Male ants, or drones, live only a few weeks or months, and are solely responsible for inseminating young queens.

Slugs and snails

The gardener's least favourite visitors, slugs and snails are quite incredible little slime balls



23. Shell
Made of calcium carbonate, a snail's strong shell will remain so if the animal's diet contains enough calcium.

1. Stomach
This section of the digestive tract receives food to be digested.

2. Kidney
During digestion, harmful side-products can accumulate and poison the snail. The kidney can expel this poison.

3. Mantle
Covering the body is a layer called the mantle, which can secrete a shell in snails but not in slugs.

5. Foot
This consists mainly of muscle tissue that contracts and expands enabling the snail to move.

4. Heart

6. Mucous gland
The mucous gland in the foot secretes thick, sticky slime to help the snail traverse tricky ground without injury.

21. Lung
Not all snails have lungs but those that do have a single cavity containing a network of blood vessels that functions like a lung.

22. Liver

20. Anus
The intestine opens outside near the anus. As the snail crawls away it leaves behind a dark trail of faeces.

13. Crop
The crop is a sack where food pulp is stored before heading to the stomach. Digestive fluids are produced by the main gland or hepatopancreas.

12. Salivary gland
Found in the buccal cavity, the salivary gland secretes saliva to aid digestion.

19. Respiratory pore
Also called a pneumostome, this breathing pore is an opening through which air is breathed into the lung.

17. Tentacle
Snails have one or two sets of retractable tentacles projecting from the top of the head depending on the species.

18. Eye
If there are two tentacles, the shorter front set will be sensitive to touch and the longer set behind will bear eyes.

16. Cerebral ganglia

15. Salivary duct

8. Dart sac
Some land snails shoot a mucus-covered 'dart' into mates, delivering a substance that improves sperm survival.

9. Vagina
Female reproductive organ located on the ventral surface of the foot.

10. Penis
Male reproductive organ is located internally when not in use and is found on the ventral face of the foot.

11. Genital pore
Found at the side of the head, this opening allows copulation and exchange of sperm.

14. Mouth
The mouth features a jaw and a rough ribbon-like tongue called the radula for grazing on plants.

Although they look very different, slugs, snails, octopuses, oysters and cuttlefish are all molluscs – Latin for 'thin shelled' – and either have a calcium-carbonate external shell, a small shell under the surface, or no shell at all. Slugs are shell-less while adult snails have coiled shells big enough to withdraw into.

Slugs and snails belong to the large group of molluscs called gastropods and make their home in a variety of locations from back gardens to oceans and everywhere in-between. They are the only molluscs that can live on dry land, and breathe using either lungs, gills or both.

Gastropods are hermaphroditic, which means they have both male and female reproductive organs, and can mate with themselves if no partner is available. During an elaborate mating ritual slugs entwine and stimulate each other until sperm is exchanged via their disproportionately large genitals. Another peculiar trait is apophallation, whereby one slug chews off the other's penis after mating. The apophallated slug may now only reproduce using its female genitalia.

Why do ticks suck blood?

Discover how these little bloodsuckers make a tasty meal of their warm-blooded hosts

Ticks are extremely small parasites that feed on the protein-rich blood of other animals through a process called 'hematophagy'. As they are arachnids they have eight legs, the first pair of which features a special sensory pit called the 'haller' organ, which can sniff out prey. After finding a suitable host, the tick anchors itself to the unwitting victim using its claws as well as its spiny legs and the special sucker pads on its feet. To puncture the skin and get to the blood, the tick uses its two fang-like chelicerae, and then extends a long serrated proboscis called a 'hypostome'. The hypostome makes it difficult to remove an attached tick as, like a fishhook, it's covered with backwards-pointing barbs. The tick then sucks up blood until its body, also known as the 'idiosoma', is so bloated it can't take any more – this can take several days.

Engorged
This image shows a tick filled with blood.

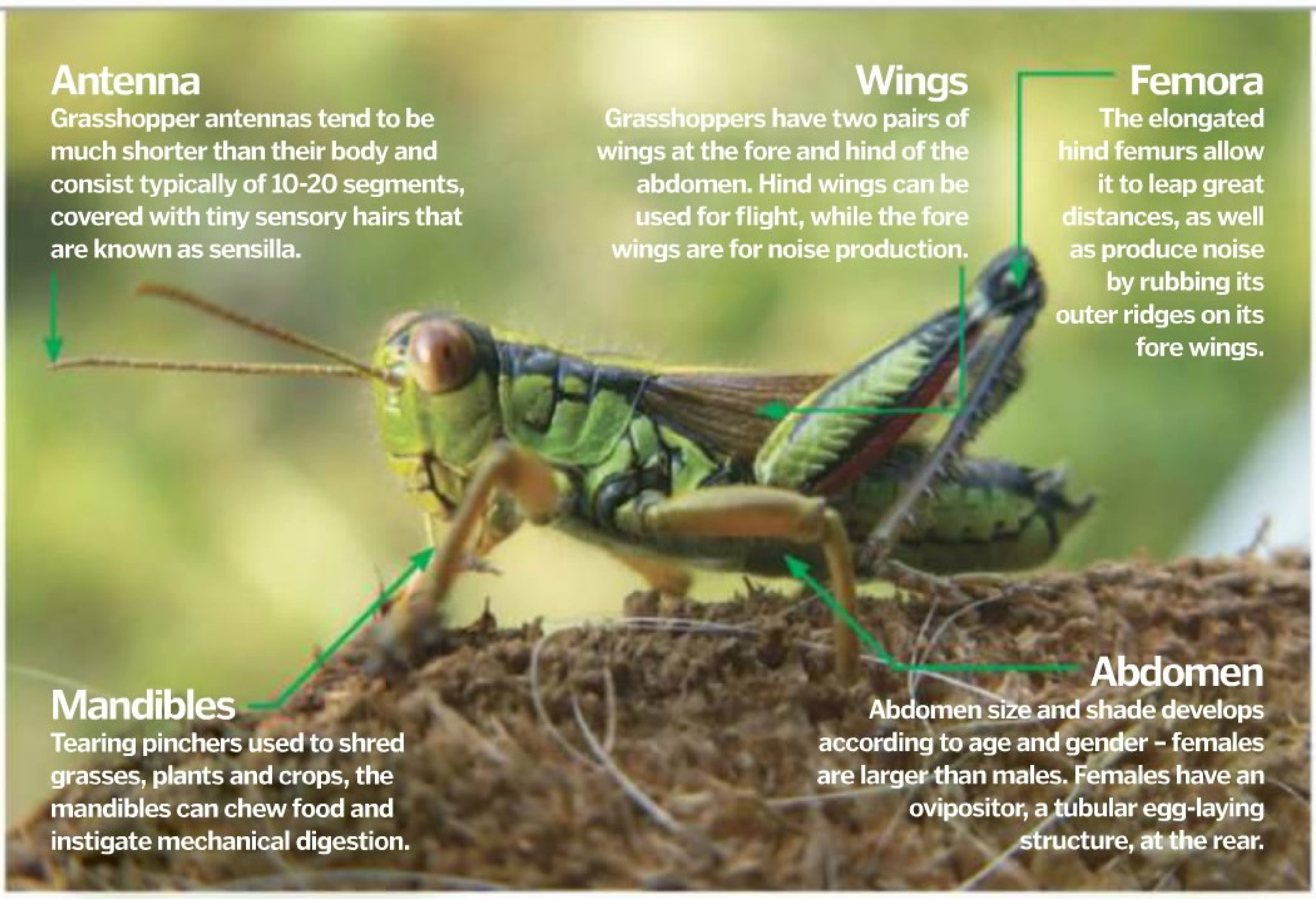
Ticks can swell to many times their size after feeding

© Science Photo Library

How to remove a tick

Always consult a doctor if you are at all concerned about a tick bite. However, it's best to remove a tick as soon as possible, as they carry such infectious diseases as lyme disease. You should avoid touching the tick, so it's a good idea to use tweezers or wear protective gloves. Then, firmly but gently, take hold of the arachnid as close to the skin as possible and pull it straight out – don't wiggle or twist, as the delicate mouthparts can break off in the skin.

Once the tick has been removed, clean the area with antiseptic (soap and water will do) to help reduce the chance of bacteria and infection.



Antenna
Grasshopper antennas tend to be much shorter than their body and consist typically of 10-20 segments, covered with tiny sensory hairs that are known as sensilla.

Wings
Grasshoppers have two pairs of wings at the fore and hind of the abdomen. Hind wings can be used for flight, while the fore wings are for noise production.

Femora
The elongated hind femurs allow it to leap great distances, as well as produce noise by rubbing its outer ridges on its fore wings.

Mandibles
Tearing pinchers used to shred grasses, plants and crops, the mandibles can chew food and instigate mechanical digestion.

Abdomen
Abdomen size and shade develops according to age and gender – females are larger than males. Females have an ovipositor, a tubular egg-laying structure, at the rear.

Grasshoppers

Renowned for their jumping prowess, grasshoppers are a diverse species of insect

Similar to the locust and cricket, the grasshopper is a species of insect in the orthoptera order, however it is non-migratory and tends to exist in isolation (ie, it does not swarm), meeting up generally only to mate.

Grasshopper anatomy consists of a long abdomen (females are equipped with an ovipositor for laying eggs), short forelegs, powerful hind legs (responsible for its jumping prowess), two pairs of wings and a short antenna. Its nervous system is controlled by a series of ganglia, a collection of nerve cells located in each part of the body – the largest occurring in the head. Information is fed to the ganglia via its antenna, sensilla (tiny exterior hairs) and cerci (paired appendages at its rear). Sound's detected by a pair of tympanal organs, a set of membranes stretched across a frame, and backed by an air sac and sensory neurons.

Grasshoppers are herbivores and tend to eat grasses, plants and leaves, dissected by their mandibles. Food is digested in a series of three guts – the stomodaeum, mesentreron and proctodaeum – running from the fore of the abdomen to the rear respectively. Food is broken down by a selection of secreted enzymes including amylase, protease, lipase and invertase. Reproduction occurs through a lengthy ovulation process (up to nine months), with eggs laid by females typically one to two inches underground.

There are currently roughly 11,000 species of grasshopper recorded worldwide, and they tend to be found residing in tropical forests and grassland planes.

A female grasshopper laying her eggs in sand. Female abdomen tips are fitted with two pairs of triangular valves to ease the digging process

© JJ Harrison

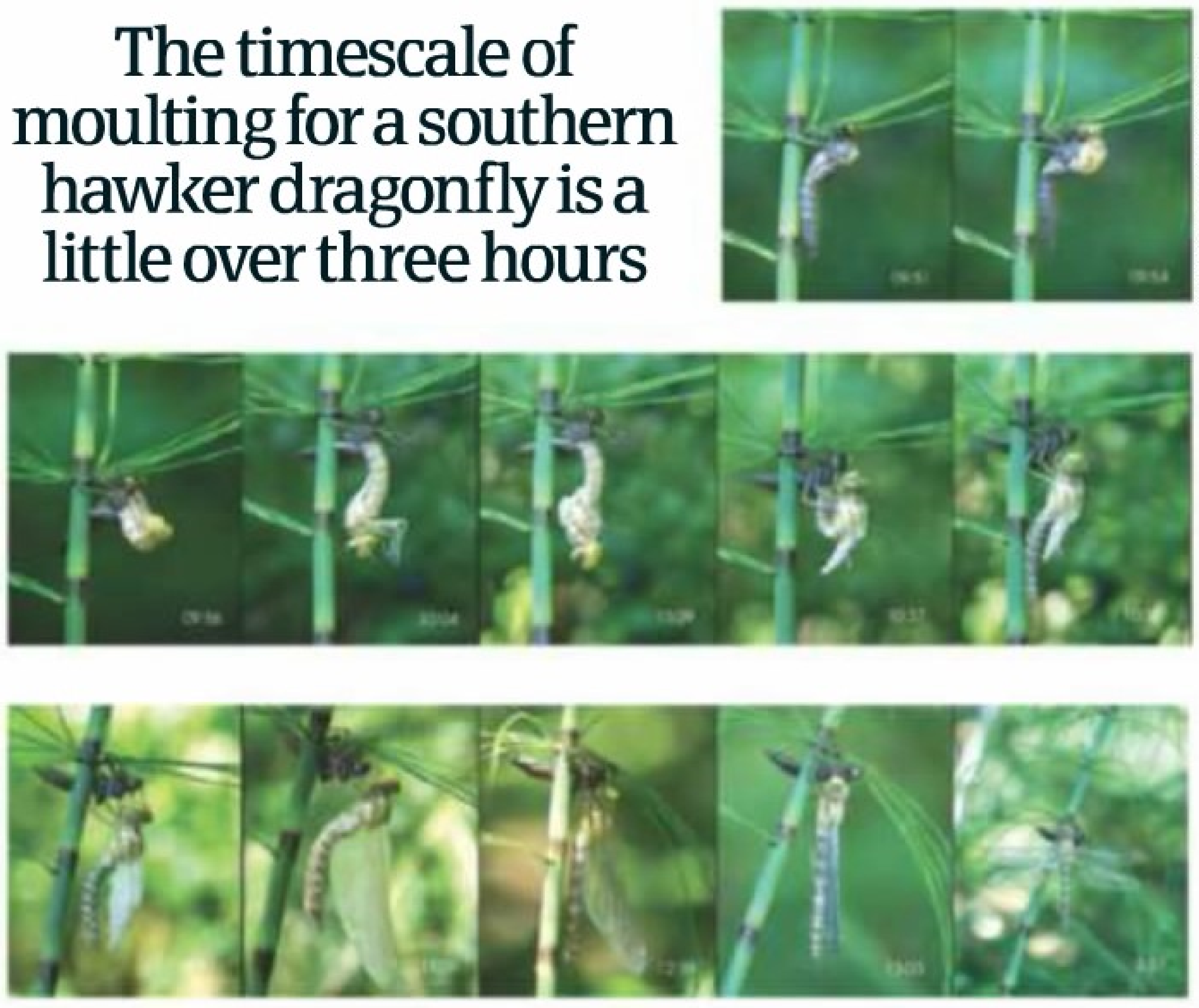
Animal moulting

It's the circle of life in all its skin-shedding glory

Creatures throughout the animal kingdom undergo the process of moulting – the replacement of their horns, hair, skin or feathers. Insects moult to allow their growing bodies to expand beyond the constraints of their rigid exoskeleton, forming a new shell in the process and often eating the old one. Most mammals shed their hair in autumn to grow a thicker layer of protection for the winter, and vice versa for the summer.

Birds moult their feathers regularly as they become worn with use, growing fresh new ones in their place. Water birds, however, often lose all their feathers at once and thus the ability to fly, meaning that they must remain hidden from predators until their feathers have re-grown. Camouflaged animals keep their pattern when they're moulting except for decorator crabs, who transfer the camouflage from their old to new exoskeleton.

Out with the old, in with the new…



The timescale of moulting for a southern hawker dragonfly is a little over three hours

© Böhringer Friedrich

Animals with exoskeletons

Why do some critters have their skeletons on the outside?

The rhinoceros beetle is considered by many as the world's strongest creature, able to carry up to 850 times its own weight!

It might come as a surprise but 98 per cent of the animals on Earth don't have a backbone, and 95 per cent don't have any bones at all. So how do all these creatures support and protect themselves? Well, many invertebrates – and all arthropods – have a protective external casing called an exoskeleton. This literally means 'outside skeleton' and its role is to cover the animal's soft tissues and also provide a rigid structure to which the creature's muscles can attach.

Insect exoskeletons are made of chitin, which is embedded into a kind of tough protein matrix. Chitin is a nitrogen-based biopolymer – similar, at least in function, to keratin, which is the stuff our hair and nails are made of. Arthropods such as crustaceans, meanwhile, have additional calcium carbonate in their exoskeletons for extra armour plating.

As well as supporting and protecting the creature, an exoskeleton also creates a watertight barrier that prevents the animal from drying out. The exterior of an exoskeleton can also contain sensory hairs or bristles, while some animals can secrete various pheromones and chemicals onto the surface of their shell as a means of repelling predators.

Though an exoskeleton consists of flexible leg joints to enable the creature to move about, once it's formed this armour does not expand with the rest of the body. Therefore, the animal will eventually outgrow it. At this point a process called ecdysis, or moulting, takes place whereby the creature will shed its overly tight outer skin in order to make way for a new one.

There are three main types of skeletal system in the animal kingdom: exoskeletons (on the outside), endoskeletons (on the inside, like humans) and hydrostatic skeletons, which are a bit different as they have no real framework but rather maintain their shape by the pressure of fluid in their bodies. Examples of creatures with hydrostatic skeletons include slugs, worms and jellyfish.

© SPL; Thinkstock; Getty

Which creatures have exoskeletons?

Scorpion

Baby scorpions start out all soft and squishy, riding around on their mothers' backs, but their exoskeletons soon harden. One unusual trait about the scorpion's exoskeleton is that it glows fluorescent under ultraviolet light.

Spider

The discarded cuticle left behind after a spider has outgrown its exoskeleton and wriggled out is complete with all the legs and you can even see the fine hairs on its body.

DID YOU KNOW? [illegible]

In Chinese medicine, cicada shells, or slough, are used to treat certain ailments

Outgrowing your shell

Until an arthropod reaches maturity, its body will continue to grow. The exoskeleton, however, does not. Whenever the shell begins to feel tight – maybe once or twice a year – it's time to grow a new one and dispose of the old. This process of moulting is known as ecdysis.

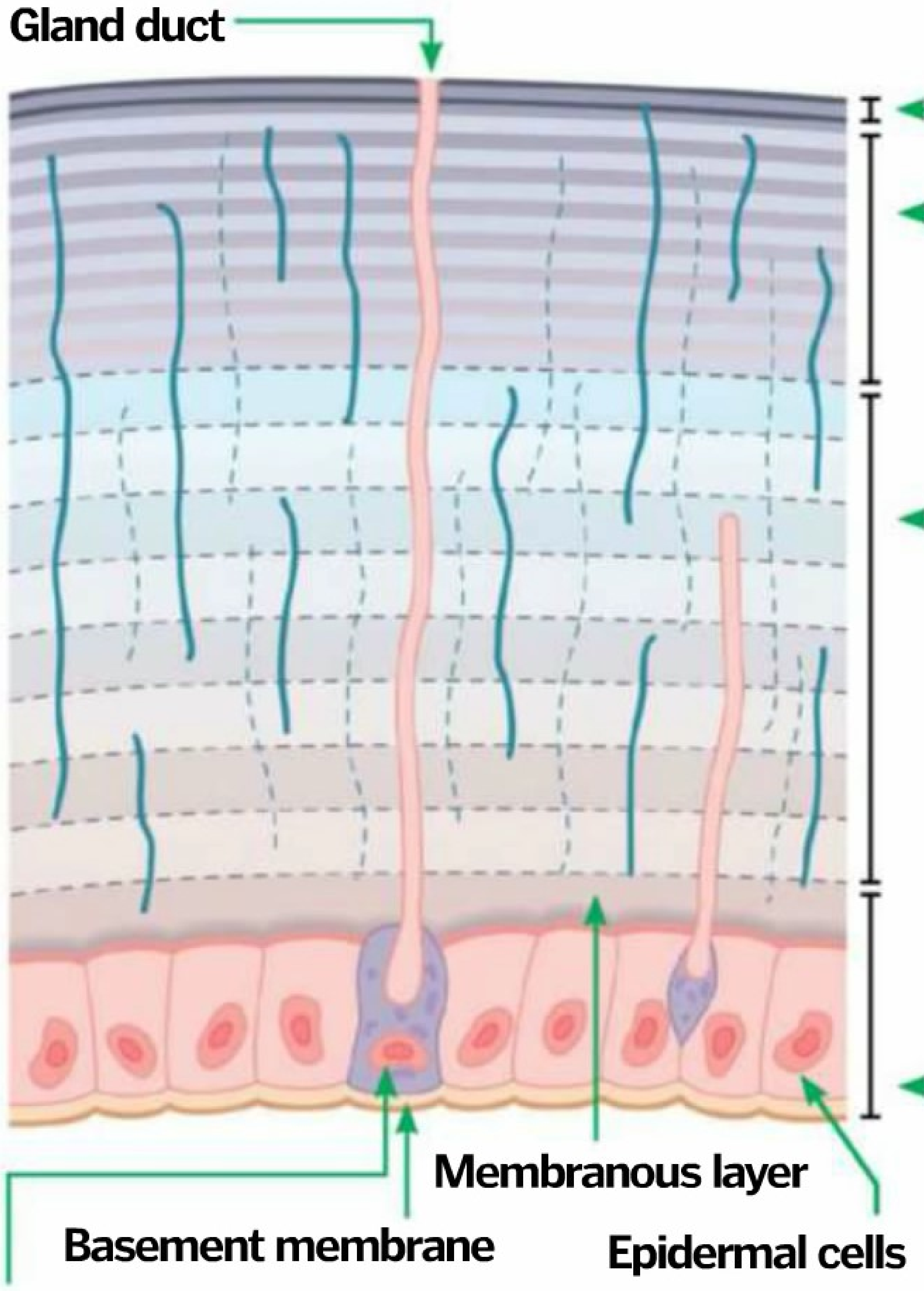
The new soft exoskeleton is produced beneath the old one, and when the time's right the old cuticle will separate from the body, enabling the animal to slip out.

Once the outer shell is cast off, the creature needs to temporarily inflate its new soft body as much as possible to create room for growth before the cuticle becomes hard again. This rapid expansion is achieved by the transferral of fluids from the animal's soft body parts to other areas. Insects that breathe through tracheal tubes can also pump up their bodies by taking in extra air.

The hardening and darkening of the cuticle is a process called sclerotisation. Superficial hardening can take a few hours, whereas permanent structural integrity and colouration can take a number of days or even weeks. Before the new exoskeleton has toughened up, the pale-bodied creature remains quite soft and is therefore very vulnerable to predators. As a result the animal will often hide away until its new shell has fully hardened.

Arthropod exoskeletons

All arthropods have an exoskeleton, aka cuticle, consisting of two main protective layers: the thin, waterproof outer epicuticle and the thicker chitinous procuticle just below it…



Epicuticle
A thin, waxy layer, the epicuticle is both water and solvent-resistant. It contains no chitin and makes up the hard exterior of the exoskeleton.

Hardened exocuticle
The thick procuticle layers are made of chitin, which is like nature's plastic. Compacted layers of this structural biopolymer produce the exoskeleton's characteristic hardness.

Flexible endocuticle
Located below the exocuticle is a criss-crossing network of further chitinous layers, which together form the tough yet flexible endocuticle layers.

Procuticle
The procuticle is made up of two main layers: the exocuticle and the endocuticle. The procuticle contains chitin microfibres bound by a protein matrix, each layer aligned differently for strength.

Epidermis
Below the cuticle layers is the epidermis, which is a single layer of secretary cells from which the epicuticle is produced.

Dermal gland
Found in the epidermis, the dermal glands are responsible for producing predator-repelling chemicals, which are released on the surface of the exoskeleton through minute ducts.

Crab

A crab's broad protective plate across its back is called the carapace. The decorator crab's exoskeleton comes in handy for disguise too, as it features tiny hooks onto which coral attaches. The coconut crab (above), meanwhile, is so big it can spend a whole month shedding its shell and waiting for the new one to harden.

Millipede

Its long, tubular exoskeleton is reinforced by hard minerals. Toxic chemicals can also be secreted onto the surface of the outer shell to deter predators or when millipedes feel threatened.

Spiny African flower mantis

A mantis will moult between five and ten times during its lifetime, and usually it will stop growing and shedding once it's an adult with fully functioning wings.

Lobster

Crustacean exoskeletons are reinforced with calcium and made up of plates. Hormones that originate from the lobster's eye tell it when it's time to shed its shell. When a chef boils a lobster its outer skin will turn from blue-black to bright red. This is because certain pigments in the exoskeleton turn red when exposed to heat.

Scorpions

The mascot of choice for international supervillains, these sinister stingers are also fearsome hunters

Arching its tail over its back, the scorpion delivers its deadly venom

Scorpions are arachnids, like spiders. However, whereas spiders are mainly ambush predators, scorpions go out looking for their lunch instead. Scorpions have between two and ten eyes, depending on the species, but their eyesight is poor and most scorpions are nocturnal anyway.

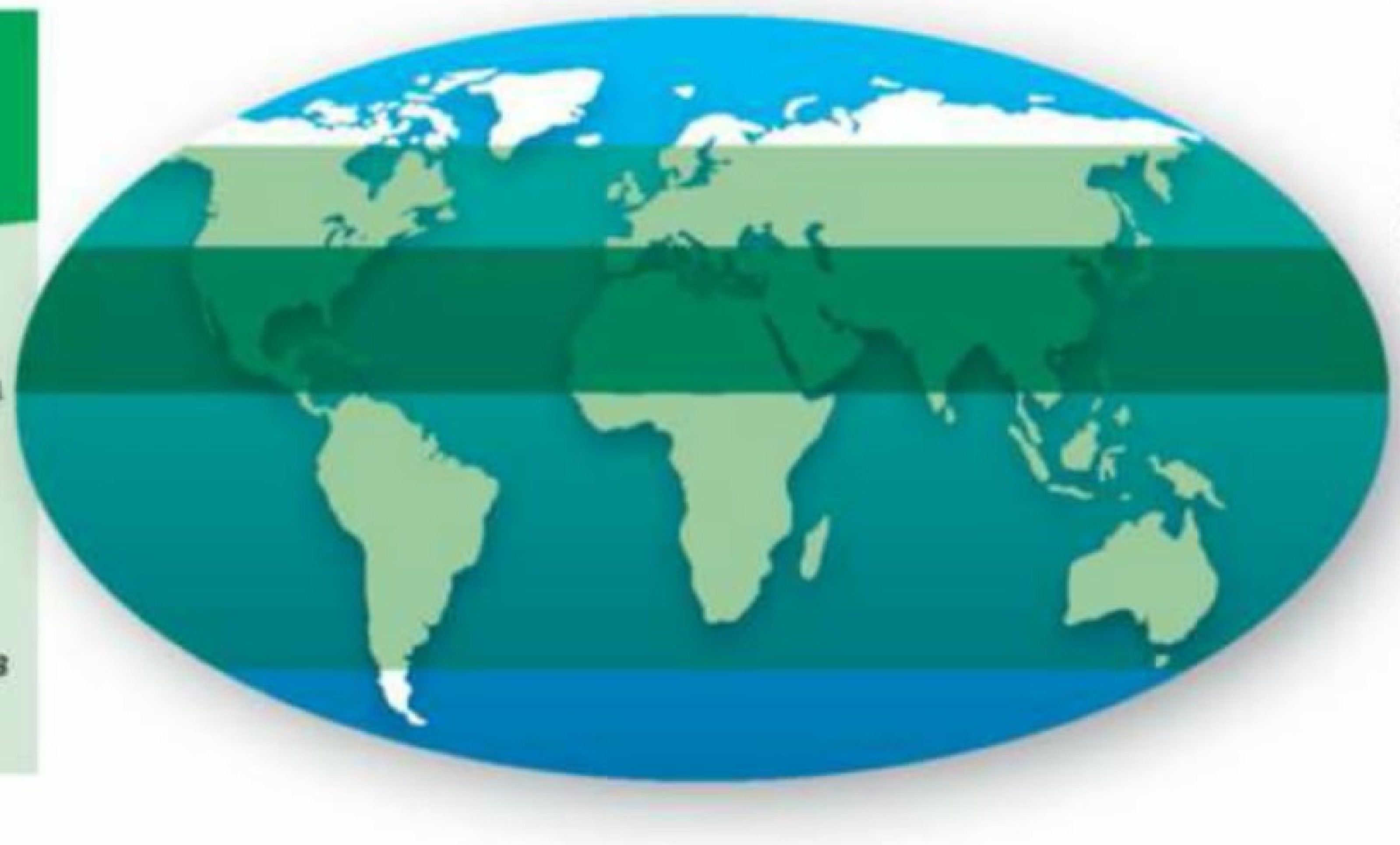
Instead they rely on vibration-sensitive legs, and hairs on their body that can detect the lightest touch or air current. A desert scorpion can feel the vibrations caused by the footsteps of a walking insect from a metre away. By comparing the time it takes the surface vibration to reach each leg, the scorpion can triangulate the position of its target. When it is close enough, the scorpion makes a brief dash to snatch its prey in powerful pincers. These claws, or chelae, are not true legs but are instead modified feelers. With the victim firmly grasped in its clutches, the scorpion arches its tail over its back to inject a powerful venom that incapacitates its meal within seconds.

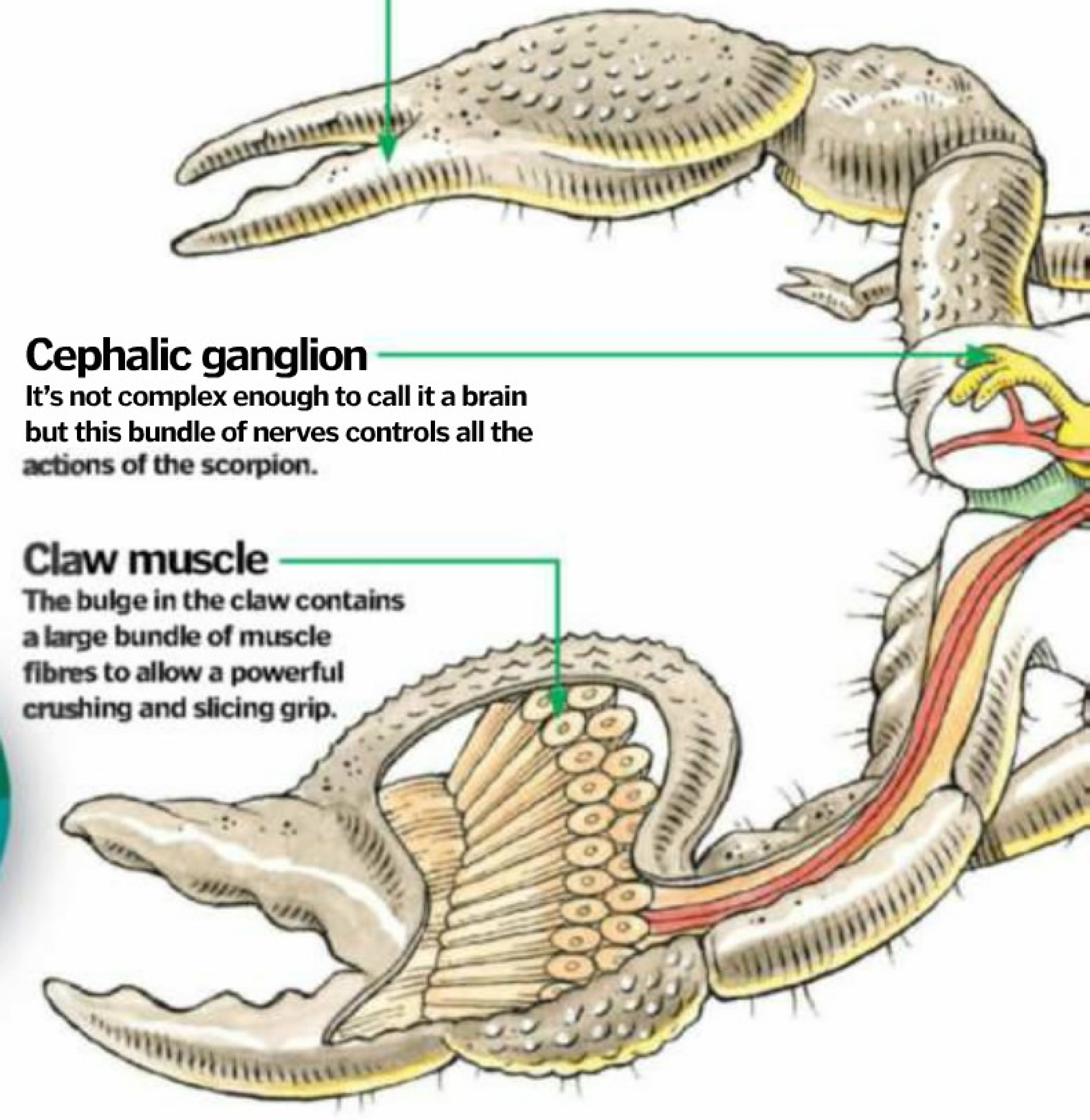
Scorpions can't eat solid food directly, so they feed in a two-stage process. First they tear off small pieces with claw-like mouthparts, called chelicerae. These morsels are placed in a small cavity under the mouth and digestive juices are squirted up from the gut like ketchup. After the enzymes have liquidised the food, it can be slurped down into the stomach. Scorpions can eat several times their body weight at a single sitting and store this away for leaner times. They have very slow metabolisms and many species live for over ten years. If necessary they can manage with just one or two meals a year.

ON THE MAP

Finding scorpions

Scorpions have a very wide distribution and are found on every continent apart from Antarctica. The dark zone on the map represents the greatest scorpion diversity but they can be found as far north as Kent in the UK and as far south as New Zealand.





Claw

The outer half of the claw is fixed and called the tarsus. The inner, movable, section is called the manus. Collectively, the pincer is called a chela.

Cephalic ganglion

It's not complex enough to call it a brain but this bundle of nerves controls all the actions of the scorpion.

Claw muscle

The bulge in the claw contains a large bundle of muscle fibres to allow a powerful crushing and slicing grip.

Head to Head
DEADLY CREATURES

DEADLY

© GG

1. Box jellyfish
The venom in the stinging tentacles will cause excruciating pain for weeks and can stop your heart. The venom also eats away your skin.

DEADLIER

© Tola Kokoza, 2009

2. Deathstalker scorpion
The most venomous scorpion. It rarely kills adults but children and the elderly are at great risk and the sting is difficult to treat.

DEADLIEST

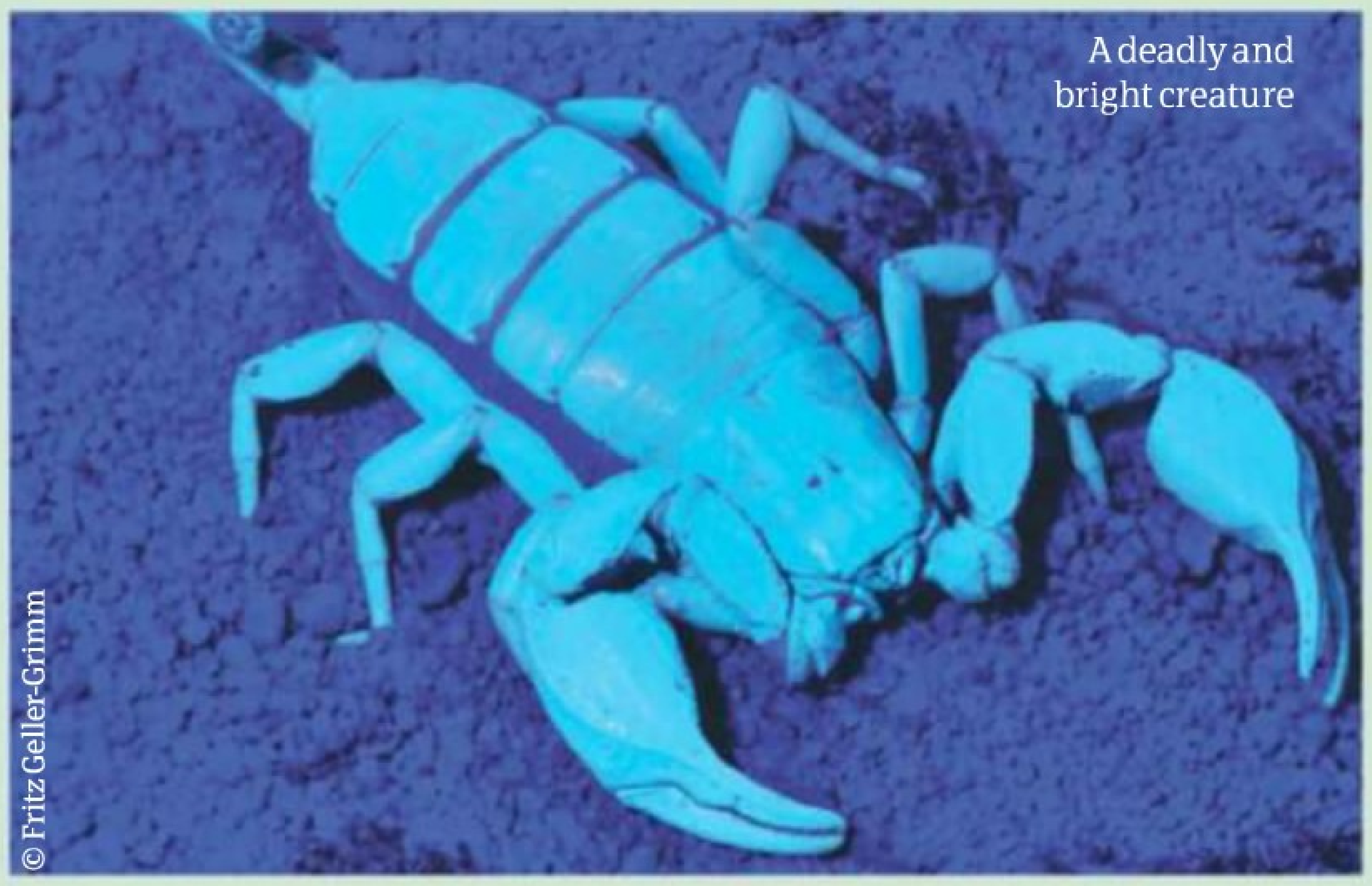
3. Funnel web spider
This large spider produces more venom than any other spider. Most mammals are immune to its bite but it will kill humans in 15 minutes.

DID YOU KNOW? Occasionally, scorpions will be born with two tails. This is caused by a random genetic mutation

All the participants in the ancient Olympics, for the first several centuries of the competition, were aristocrats

Party animals
How do scorpions glow in ultraviolet?

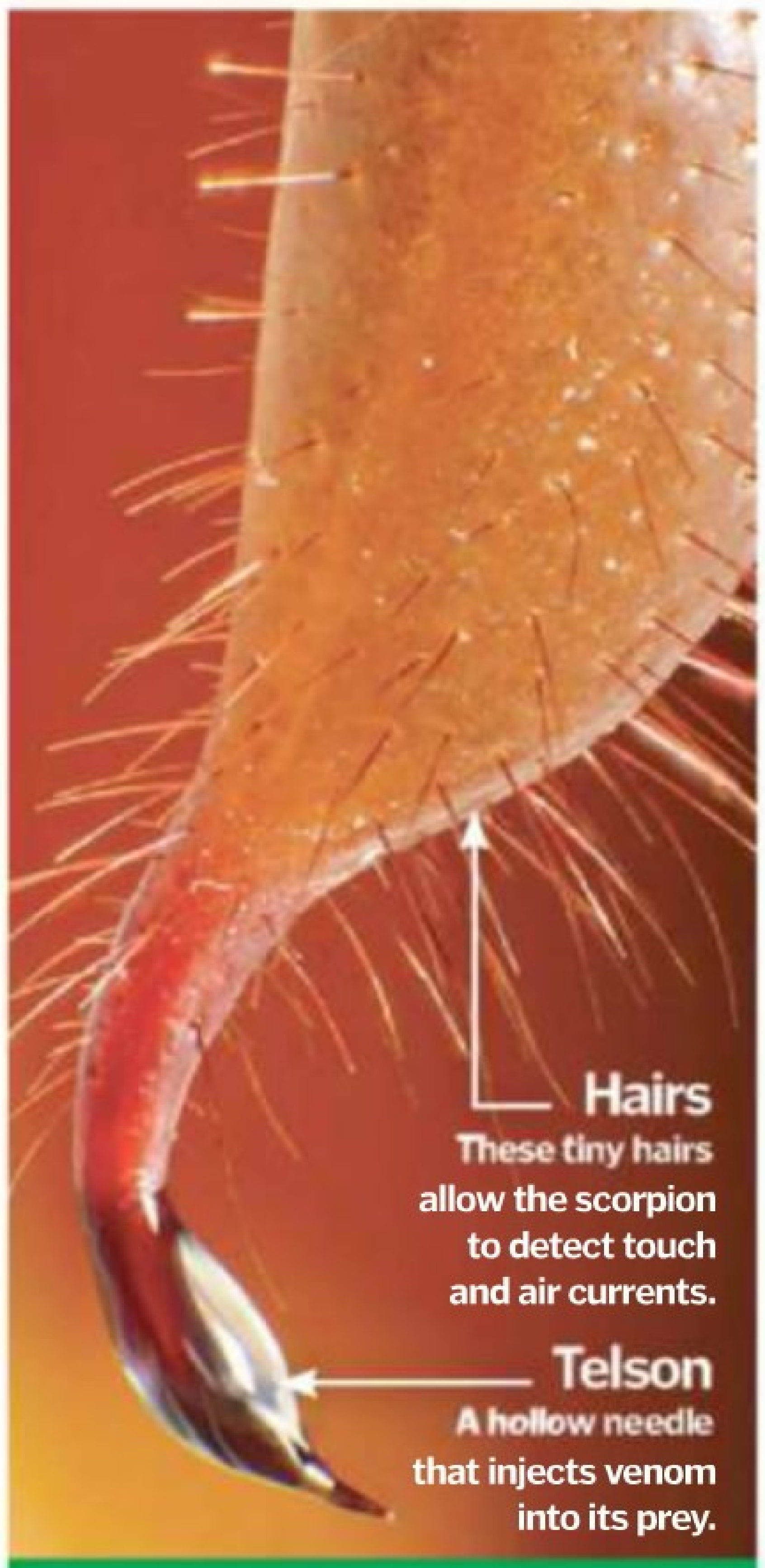
All scorpions are fluorescent. This means that they glow when shone with ultraviolet light. This rather funky property is an accidental side effect of the way their armour plating is constructed. When scorpions first shed their skin, the new skin underneath is soft and vulnerable. To harden it up, the protein chains are cross-linked using other compounds. This process is called sclerotisation and is similar to the way that cowhide is turned into leather. In scorpions, the cross-linking compound is beta-carboline, which is strongly fluorescent. As a result scorpions glow more and more brightly under UV light with each successive moult.


A deadly and bright creature

© Fritz Geller-Grimm

Only 25 species have venom capable of killing a human

© Siga

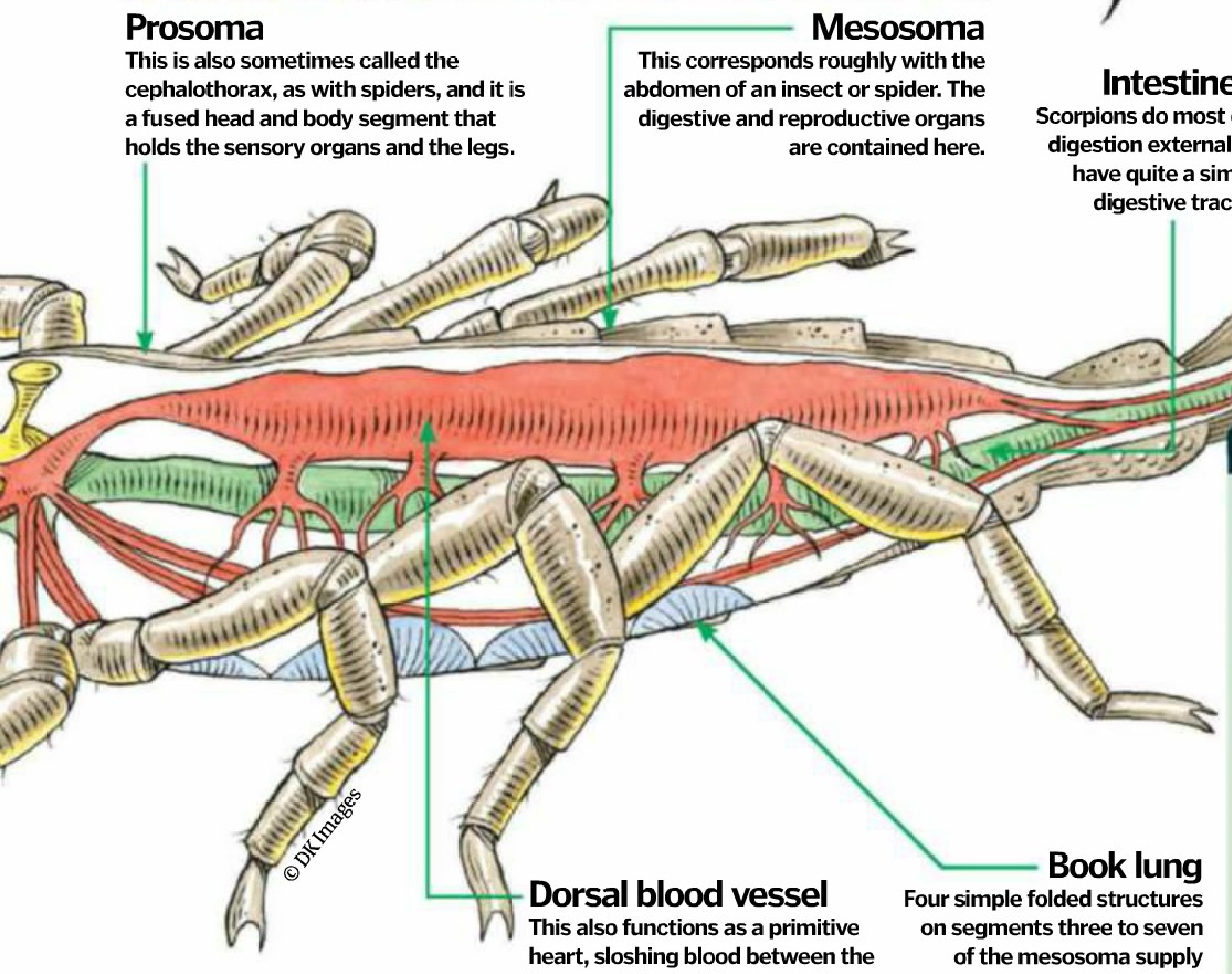

Hairs
These tiny hairs allow the scorpion to detect touch and air currents.

Telson
A hollow needle that injects venom into its prey.

Sting in the tail

Scorpions are fast, strong and armoured, but they aren't invulnerable and relying on sheer brute strength when you are tackling prey almost as large as you is always risky. To tilt the scales in their favour, all scorpions are equipped with fast-acting venom which is delivered through a hollow barb located on the end of their tail.

Scorpion venom is a cocktail of hundreds of different neurotoxins and enzyme inhibitors. This broad spectrum of chemicals allows the scorpion to target several different biological systems at once; some compounds paralyse muscles, others cause cell damage. Scorpions have also evolved different toxins to target different animals. For example, insect and mammal nervous systems work in quite different ways, and by combining all these chemicals into a single venom, scorpions have created a silver bullet that can take down almost anything. Despite this, our sheer size is our biggest defence and only 25 species of scorpion are deadly to humans.


© DK Images

Telson
The sting or telson is a hollow needle that injects the venom. The two poison glands can adjust the dose according to the size of prey.

Metasoma
The tail is made from the last six segments of the body. The anus opens at the end, just before the sting.

Prosoma
This is also sometimes called the cephalothorax, as with spiders, and it is a fused head and body segment that holds the sensory organs and the legs.

Mesosoma
This corresponds roughly with the abdomen of an insect or spider. The digestive and reproductive organs are contained here.

Intestine
Scorpions do most of their digestion externally and have quite a simple digestive tract.

Dorsal blood vessel
This also functions as a primitive heart, sloshing blood between the lungs and the bodily extremities.

Book lung
Four simple folded structures on segments three to seven of the mesosoma supply oxygen to the blood.

The statistics…

© Danny Steaven

Scorpions

Type: Arachnid

Diet: Carnivore

Average life span in the wild: 4-25 years

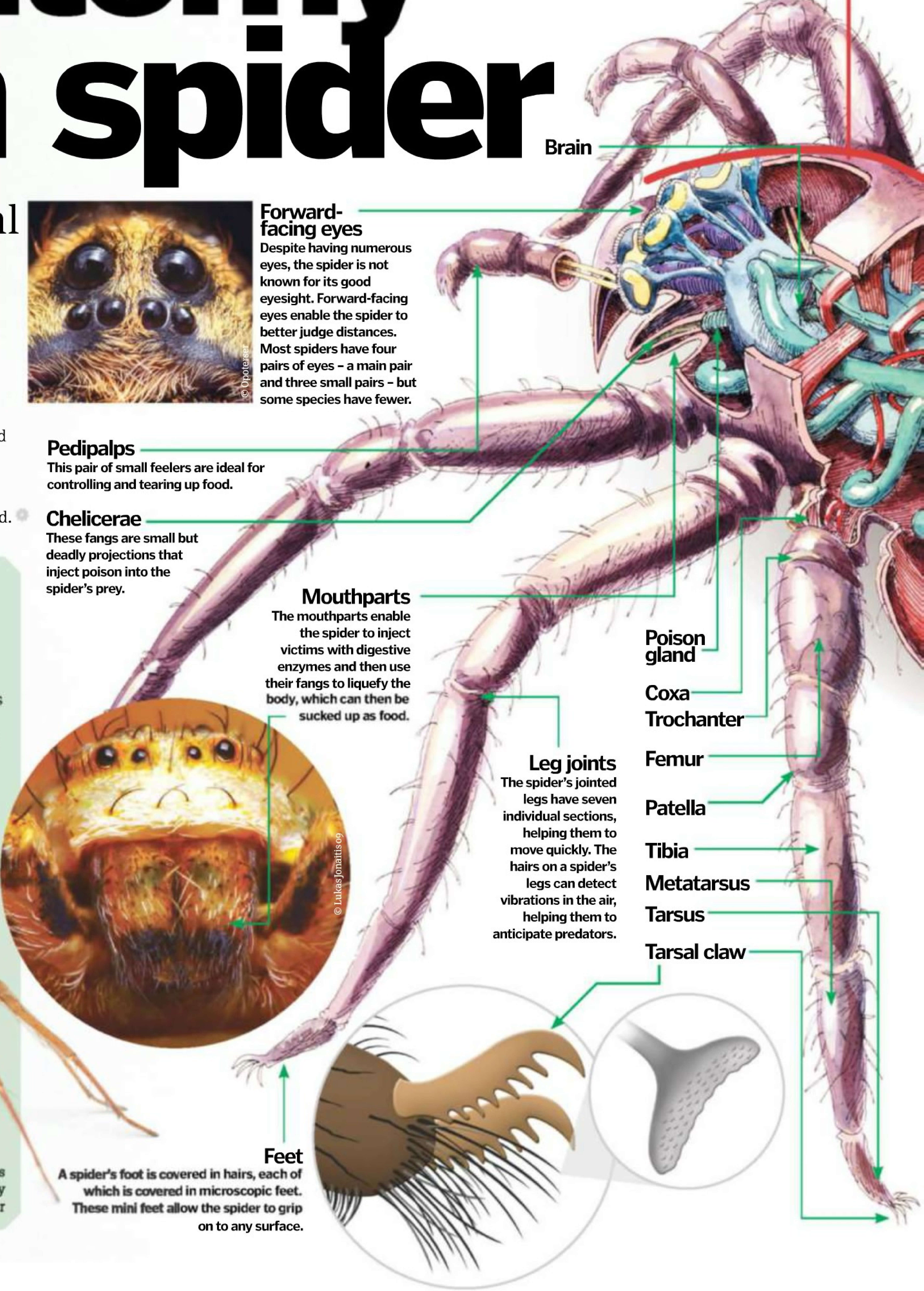
Weight: 4-60g

Size: 12mm-20cm

Anatomy of a spider

Inside the animal behind the most common phobia in Britain

Part of the arachnid class of animals – which actually includes scorpions, ticks and mites – spiders are eight-legged arthropods with two body sections. With its ability to inject venom into its prey, immobilising them for ease of eating, the spider has become both feared and revered.



© Opoteser

© Lukas Jonaitis 09

Cephalothorax
The cephalothorax is the fusion of head and thorax that distinguishes spiders from insects, which have three separate head, thorax and abdomen sections. This large section of the spider's body carries four pairs of legs and two pairs of mouthparts.

Forward-facing eyes
Despite having numerous eyes, the spider is not known for its good eyesight. Forward-facing eyes enable the spider to better judge distances. Most spiders have four pairs of eyes – a main pair and three small pairs – but some species have fewer.

Pedipalps
This pair of small feelers are ideal for controlling and tearing up food.

Chelicerae
These fangs are small but deadly projections that inject poison into the spider's prey.

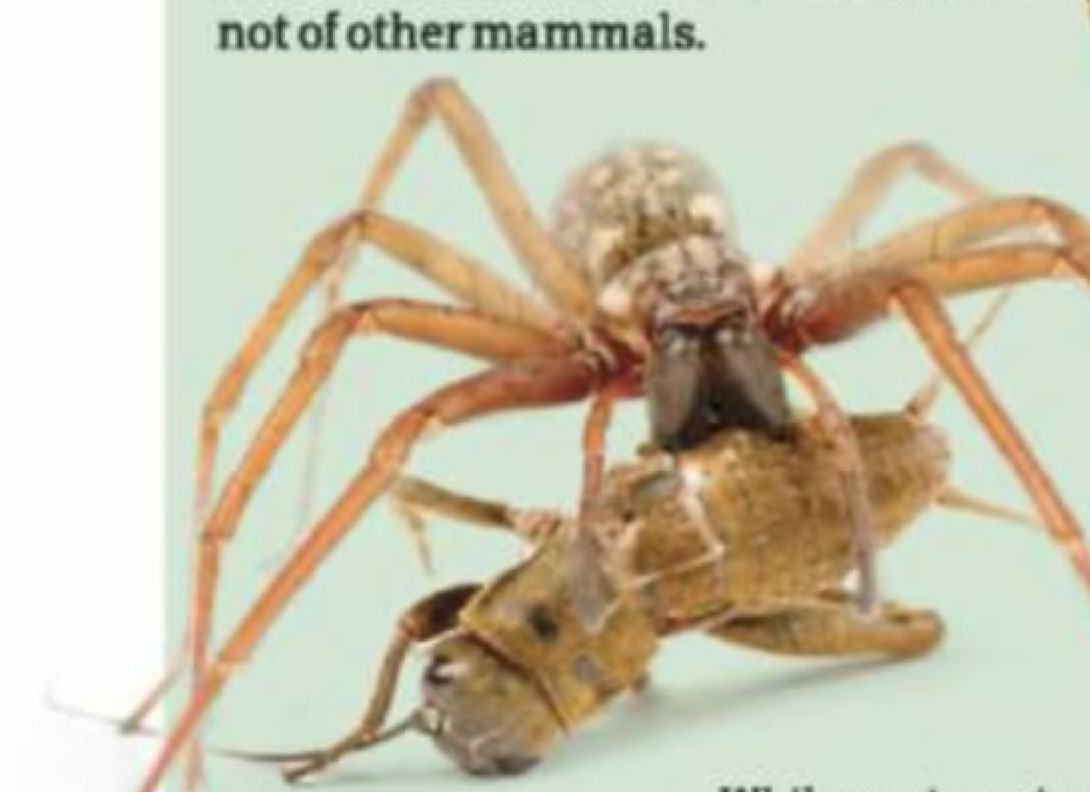
Mouthparts
The mouthparts enable the spider to inject victims with digestive enzymes and then use their fangs to liquefy the body, which can then be sucked up as food.

Leg joints
The spider's jointed legs have seven individual sections, helping them to move quickly. The hairs on a spider's legs can detect vibrations in the air, helping them to anticipate predators.

Feet
A spider's foot is covered in hairs, each of which is covered in microscopic feet. These mini feet allow the spider to grip on to any surface.

Fancy a bite?

The poison gland connected to a venomous spider's fangs contains dangerous chemicals that are released into a victim by digging the fangs into the victim's body. Unless the spider feels threatened, these fangs will remain tucked away. Some spider poisons have horrible side effects, including tissue degeneration, cell death, and sickness, and yet even if a deadly venomous spider does bite you, your chance of dying as a result of it is less than ten per cent. Male funnel-web venom contains robustoxin, which affects the nervous systems of humans and monkeys, but not of other mammals.



While most species have trachea and book lung respiratory systems, some just have one or the other

© Jarich

5 TOP FACTS SPIDERS

Good vibrations

1 Spiders do have eyes but they aren't very effective. Instead, spiders use vibrations. The tiny bristles all over a spider's body surface are sensitive to touch, vibration and airflow.

Spiders' digest

2 Spiders digest food outside their body. They cover the insects in digestive enzymes which break down the body, and allows the spider to suck up the liquid prey.

Arthropods

3 Spiders are arthropods, so the skeletal system of their body is the outermost layer. The hard exoskeleton helps the spider maintain moisture and not dry out.

Special silk

4 Spider silk has other uses than spinning webs. Black widow silk was at one time used in military gun sights because of its strength and uniform thickness.

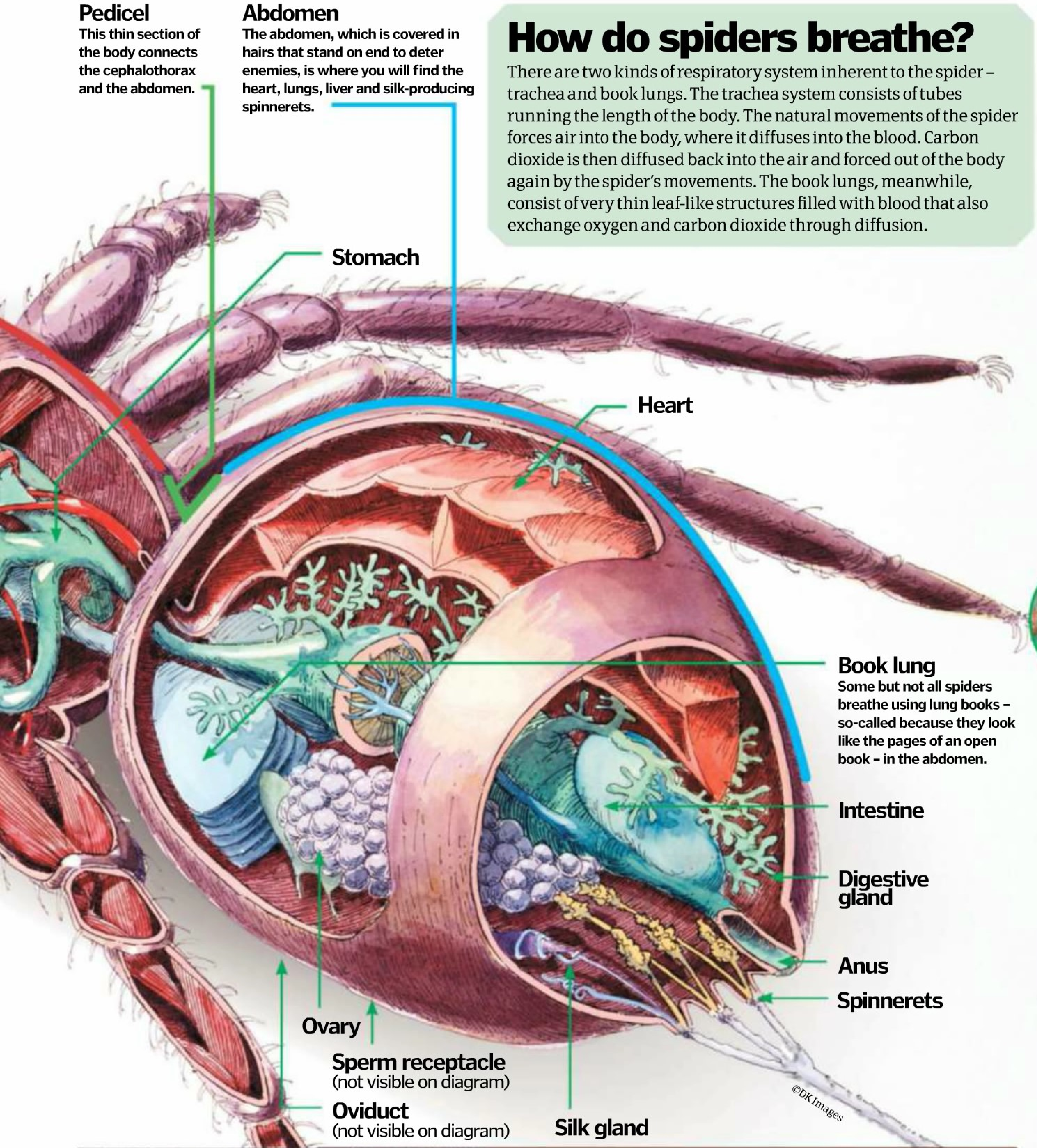
Flying spiders

5 Young spiders, or spiderlings, can travel great distances by doing something called 'ballooning' – the process of floating on the breeze using a strand of silk.

DID YOU KNOW? *If a train was to hit a sheet of spider's silk the thickness of a pencil it would stop the vehicle in its tracks*

How do spiders breathe?

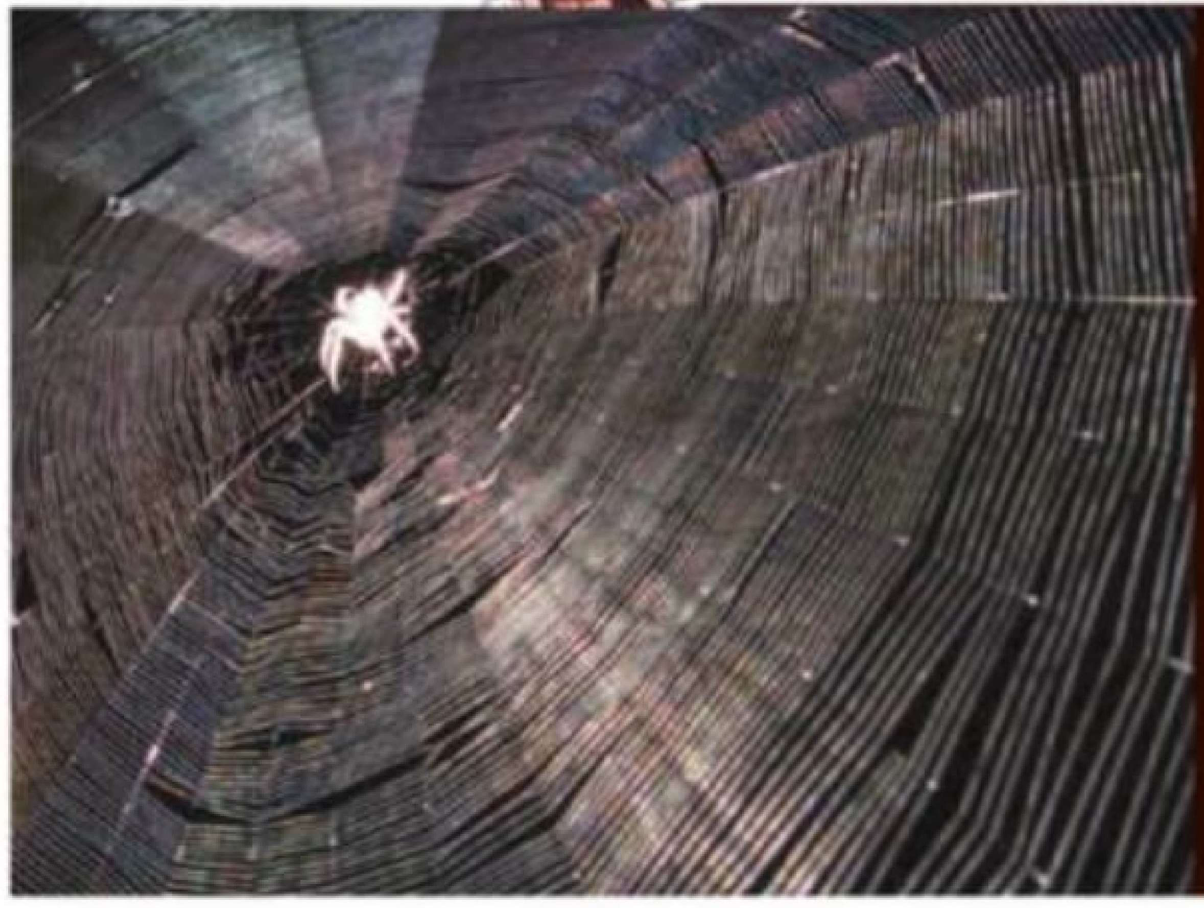
There are two kinds of respiratory system inherent to the spider – trachea and book lungs. The trachea system consists of tubes running the length of the body. The natural movements of the spider forces air into the body, where it diffuses into the blood. Carbon dioxide is then diffused back into the air and forced out of the body again by the spider's movements. The book lungs, meanwhile, consist of very thin leaf-like structures filled with blood that also exchange oxygen and carbon dioxide through diffusion.


Pedicel
This thin section of the body connects the cephalothorax and the abdomen.

Abdomen
The abdomen, which is covered in hairs that stand on end to deter enemies, is where you will find the heart, lungs, liver and silk-producing spinnerets.

Book lung
Some but not all spiders breathe using lung books – so-called because they look like the pages of an open book – in the abdomen.

Nature's strongest fibre



Weight for weight, spider silk is stronger than steel. Produced in the silk gland ina the abdomen, the silk is made from proteins called fibroin. It's exuded as a liquid that hardens on contact with the air when the molecular structure is aligned by the spider pulling it with its legs. The spider squeezes the silk from the tail end of its body using structures called spinnerets. It then uses its legs to stretch the material into long threads for weaving into webs to catch prey.

MOST WANTED

Some of the most notorious spiders on the planet

1 Brown recluse

The brown recluse can be distinguished by the dark violin-shaped marking on its back. It uses stealth – not a web – to catch its prey by sneaking up and sinking its venomous fangs into the victim. Most bites to humans are accidental and painless, until three to eight hours later when the site becomes red and painful. In bad cases the wound becomes necrotic causing the cells and tissue to die, which can leave severe scarring.

2 Black widow

Identified by their vivid red-on-black markings, black widows are found in the more temperate regions of the globe. Though the venom can bring about nasty symptoms in adults, a bite from the black widow doesn't actually sound the death knell for its victims. Children and the elderly, however, are more at risk.

3 Mexican redknee tarantula

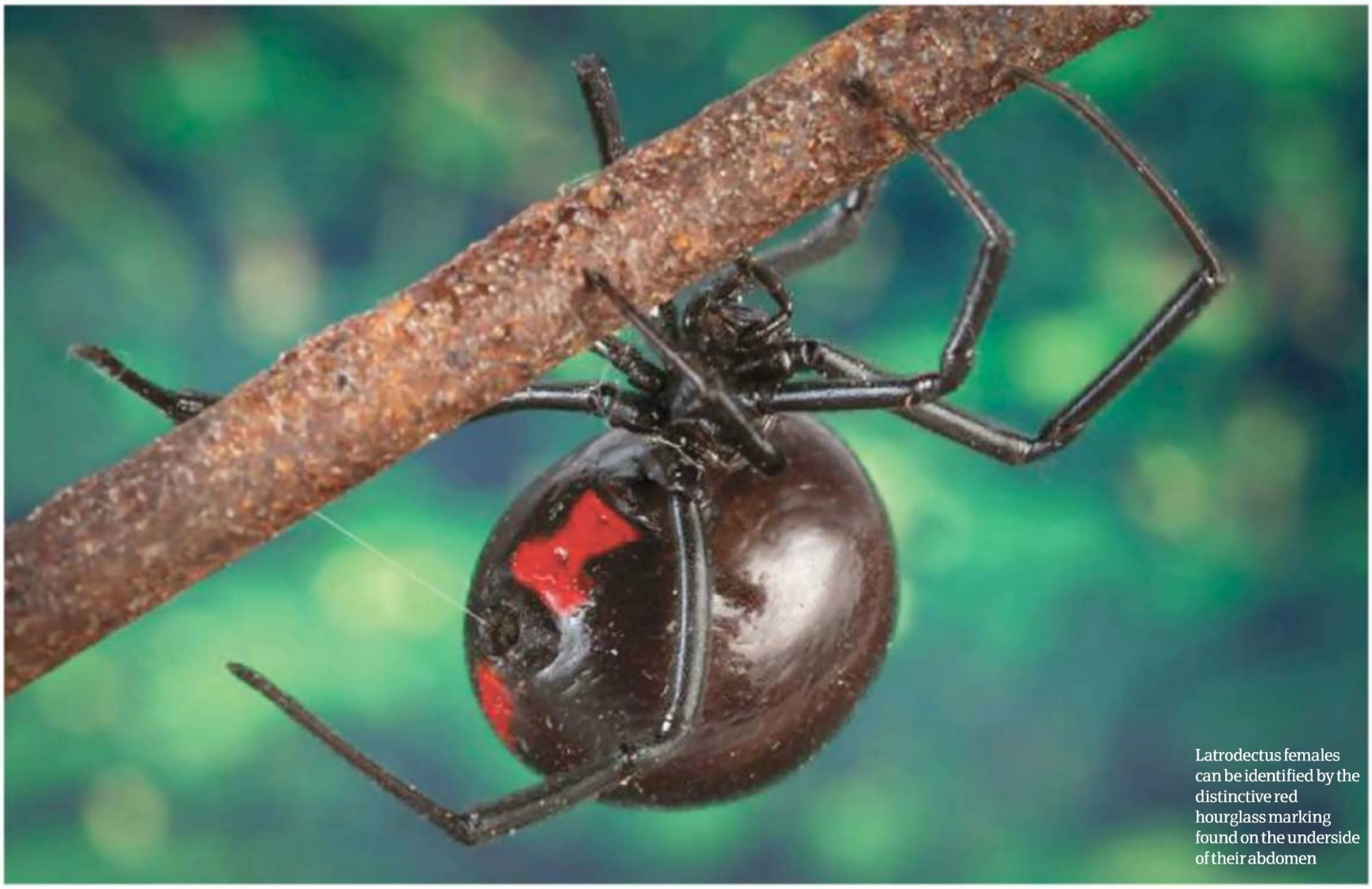
The Mexican redknee is most wanted not because it's a deadly creature but because it makes for a popular pet. Found in the mountains of Mexico and often employed for its impressive appearance as a Hollywood prop in the likes of the *Indiana Jones* and *James Bond* films, this spider is actually very docile and moves very slowly.

4 Wolf spider

Mottled brown in colour – and therefore often confused with the brown recluse (above) – the wolf spider is so-named because it was once thought to have hunted in packs. Though wolf spiders are hairy, they are not closely related to the tarantula. Wolf spiders are not poisonous unless you're allergic, and they can be found throughout Europe and in Britain.

5 Funnel-web spider

A native to the coastal and mountain regions of eastern Australia, the funnel-web is a small but deadly part of the family. Its glossy, almost hairless body gives it a menacing appearance and some species can serve a highly toxic, fast-acting venom. The female funnel-web will spend most of her life inside her burrow, which is lined with white silk.



Latrodectus females can be identified by the distinctive red hourglass marking found on the underside of their abdomen

sxc.hu

While their bites are dangerous to humans, black widows don't usually bite unless acting defensively

DID YOU KNOW?

The poison of the black widow spider is 15 times stronger than a rattlesnake's venom. It rarely bites humans and although painful, less than 1% of them cause human death.

Black widows

How do these deadly spiders kill their prey?

The black widow spider (genus Latrodectus) begins by using its silk glands (spinnerets) at the rear of its abdomen to create a sticky web. It waits at the edge of the trap until its prey either flies or walks into it. When an insect is trapped in the web, the black widow can sense the vibrations caused by the struggling prey. From these vibrations it can tell how big and strong the prey is, and if it is too big, it will leave well alone.

If the prey is small enough, however, the black widow will use its spinnerets to cover it in stronger webbing. It then firmly holds the prey with its chelicerae, which is a pair of hollow appendages above its mouth that send poison into the victim.

The spider's latrotoxin, neurotoxic poison, causes the prey to suffer spasms, paralysis and death within ten minutes. After this, enzymes inside the victim liquefy its body allowing the spider to feed on it.

How does a spider construct its web?

The spinnerets in action, here being used to cocoon a victim

© Alamy

Learn how arachnids create their spiral orb webs in which to ensnare prey

Building a spider web is a very complex process. Referring to the stages below, first the spider (at point A) dangles a length of sticky silk, which can be carried in the air until it sticks to an anchor point, such as a branch (see point B). Once the silk is attached to point B, the spider pulls it taut and fixes the original end to anchor point A, creating the 'bridge thread' (red).

Now the spider fixes a second strand (blue) to point A and spins this while crossing the bridge. This thread is looser than the first and droops below the bridge thread. At point B the spider attaches this strand but doesn't pull it taut.

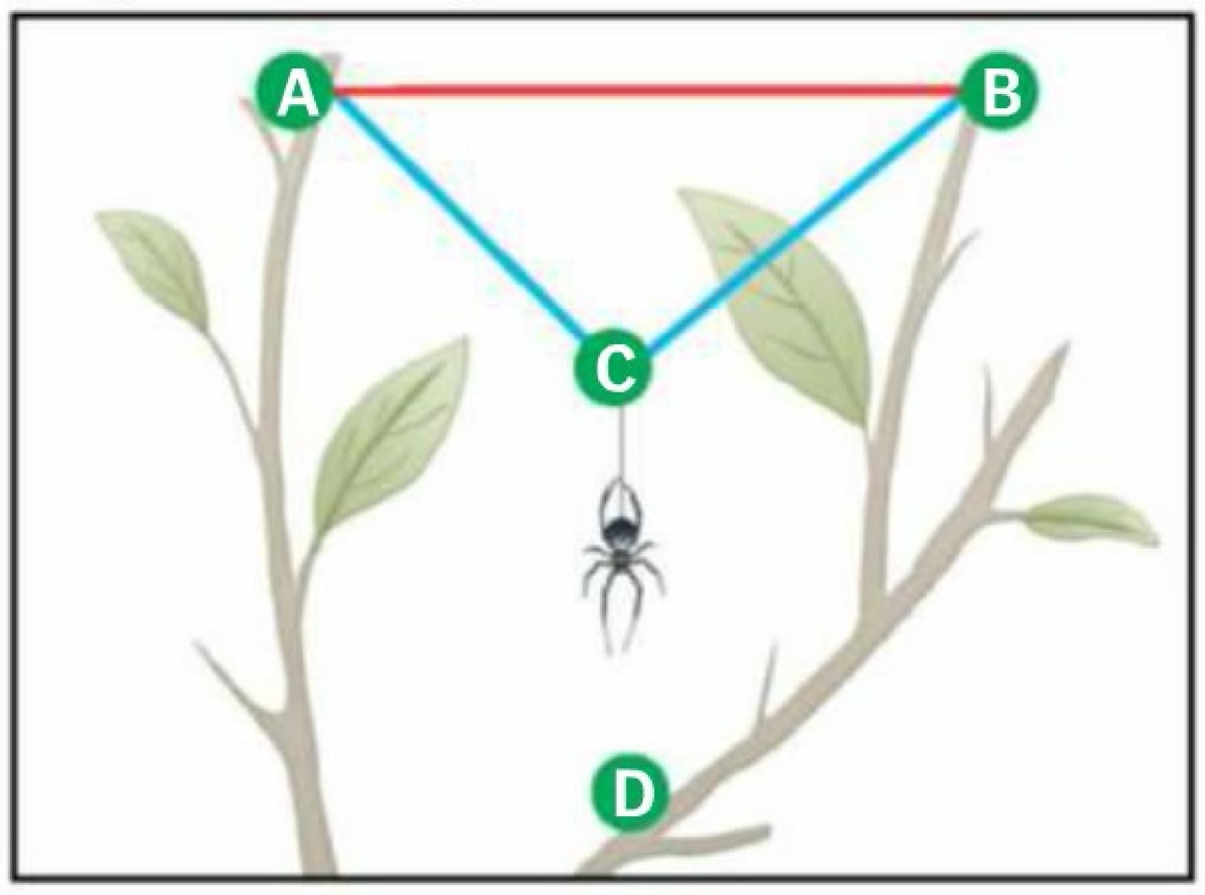
Next the spider travels back halfway along the now anchored loose thread (to point C; the web centre); the weight of the spider bows the thread into a V-shape, and from the bottom of the 'V', the spider attaches a third thread, which is spun as the arachnid descends to another branch (anchor point D). This turns the V-shape into a Y-shape, and creates another integral pathway. The spider continues to create more of these structural strands until a basic framework is in place.

With the main frame lines in position, the spider adds radial threads from the centre to surrounding vegetation, much like the spokes of a wheel. These form the non-stick paths upon which the creature can safely navigate its trap.

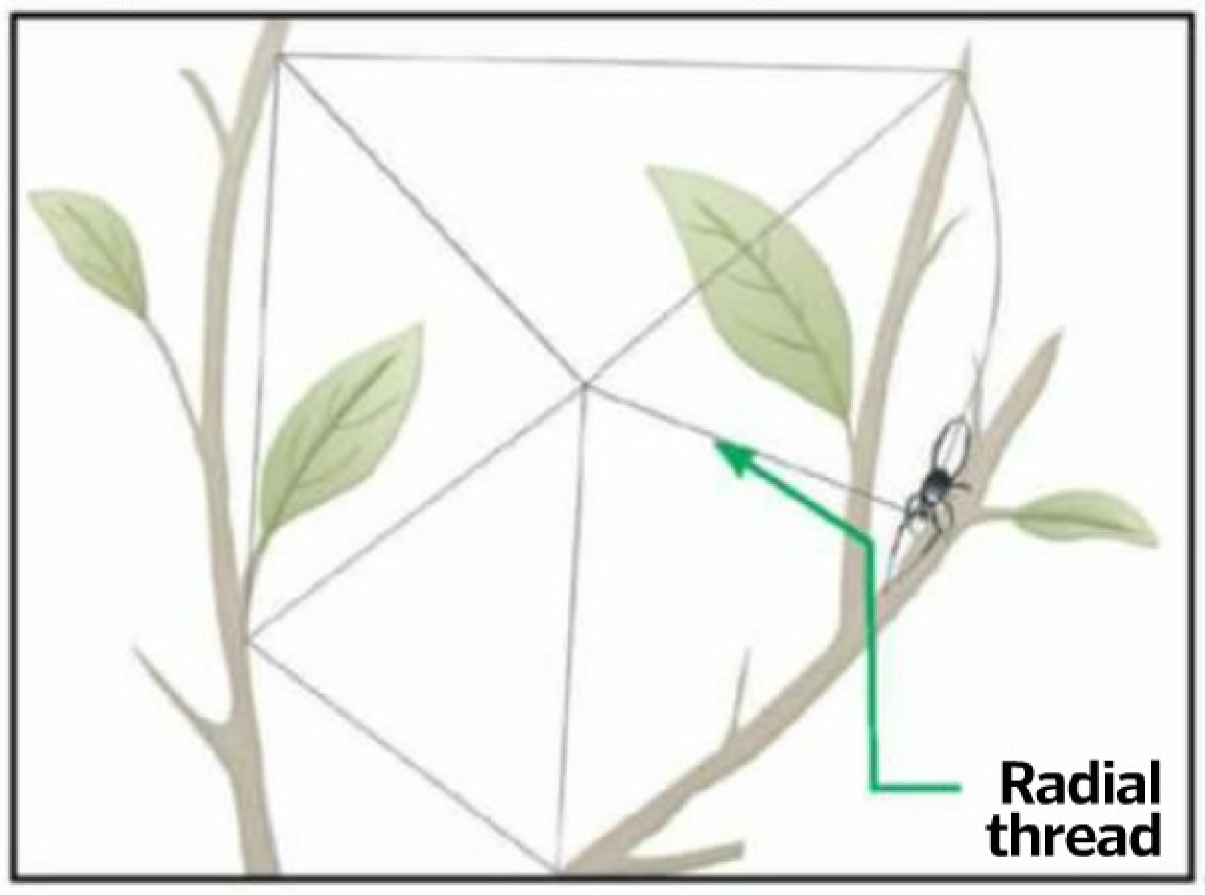
Next the spider creates a silk spiral across the radial lines from the inside out. Using this as a template, it repeats this stage, except this time the threads are coated in bug-catching adhesive.

Now all the spider needs to do is position itself at the centre of its trap and wait. These creatures are very sensitive to vibrations and, quick as a flash, the spider can expertly traverse its web to confront a haplessly entangled victim.

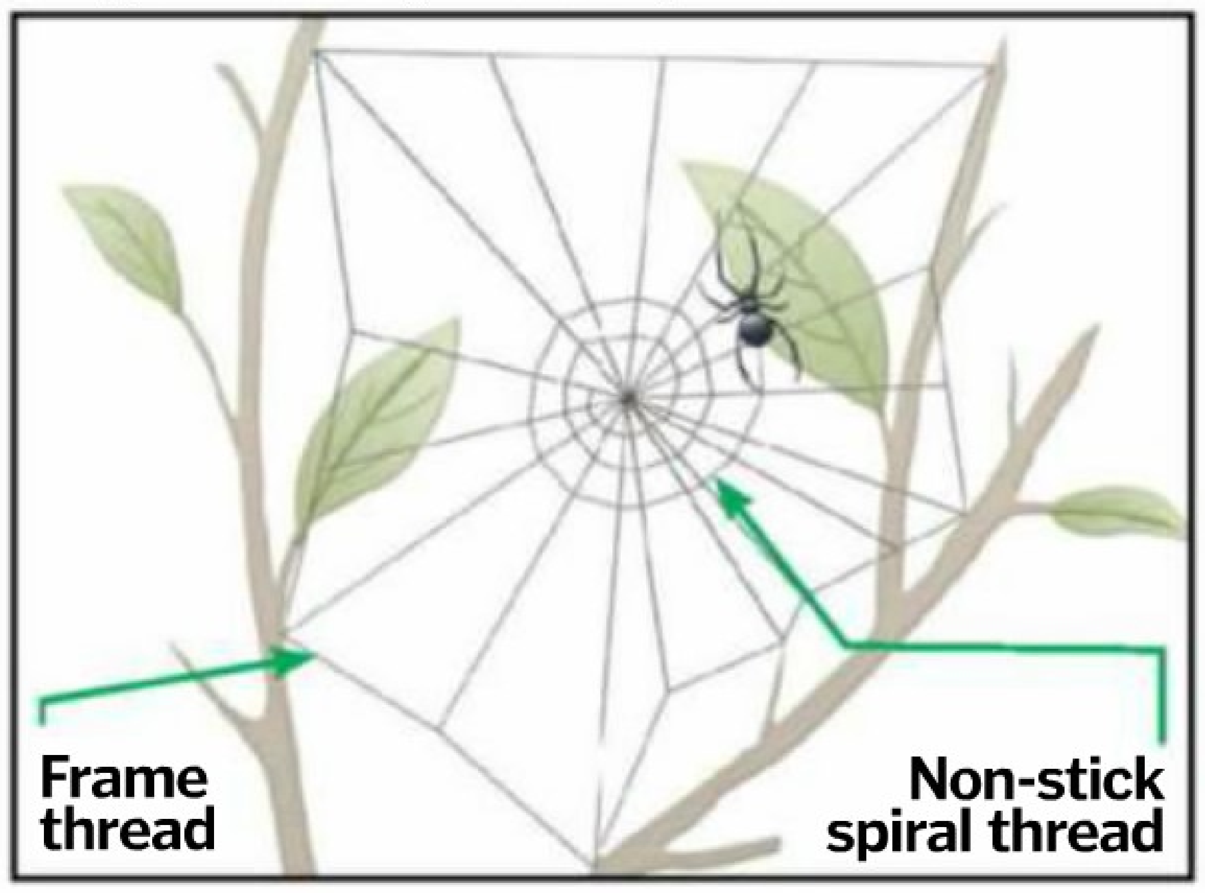
Stage 1: Creating a framework



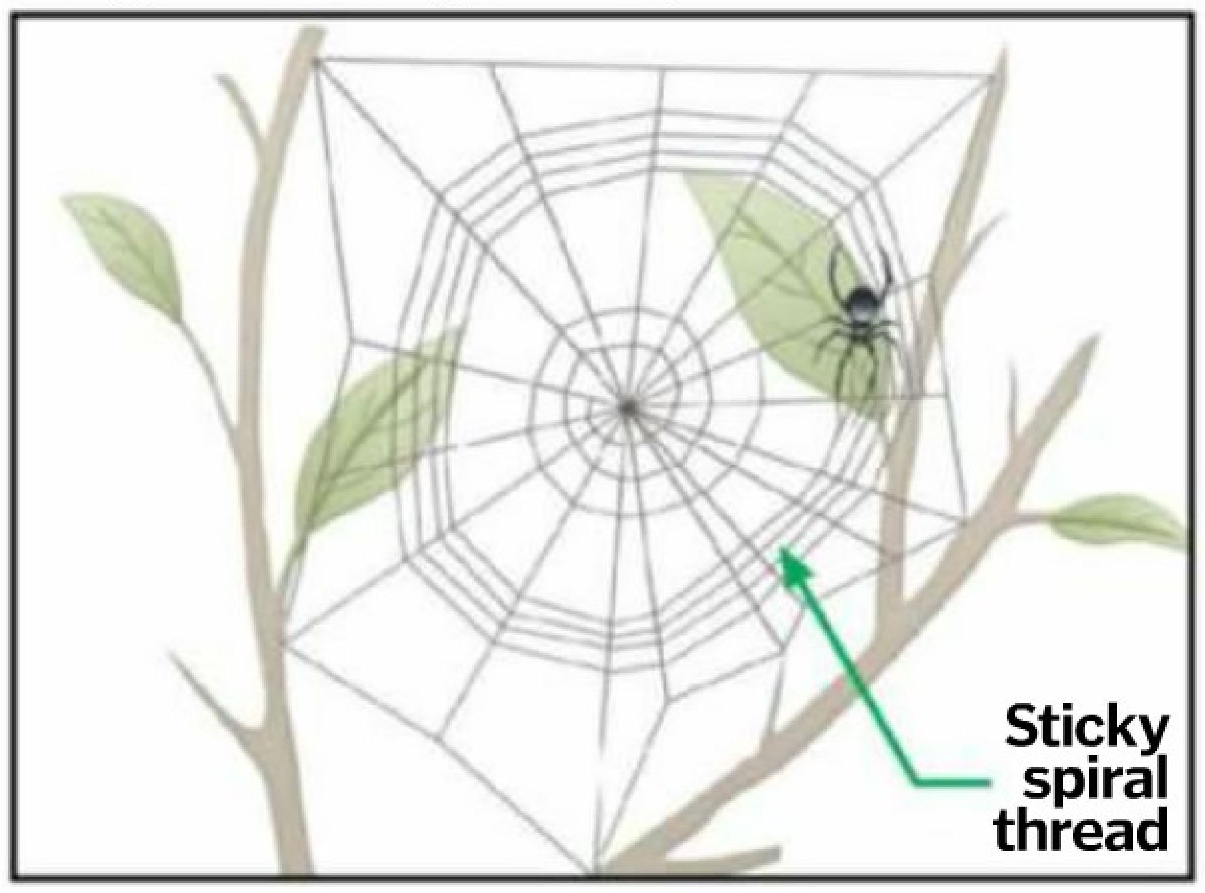
Stage 2: The orb takes shape



Stage 3: The spiral template



Stage 4: Setting the trap

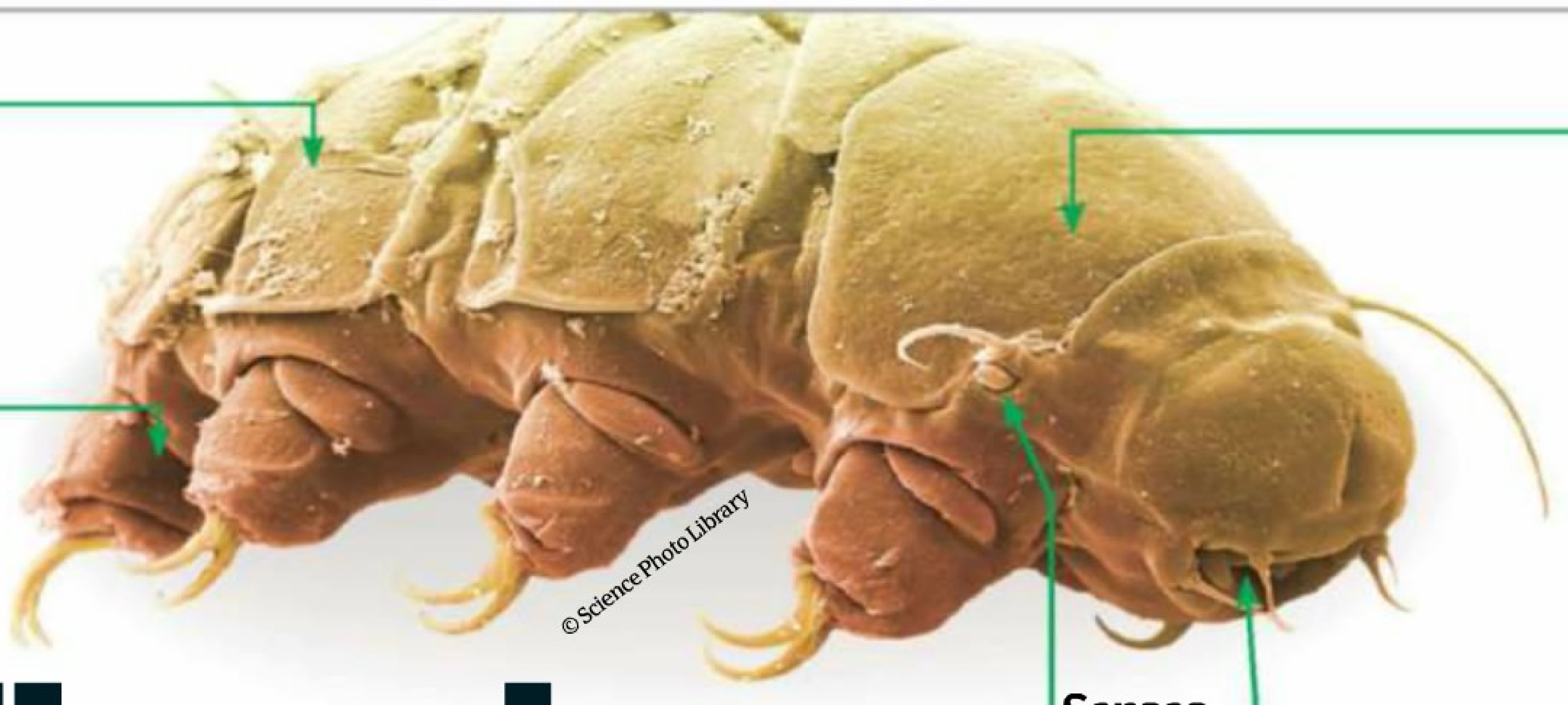


The science of silk

Spider silk is made of proteins called fibroins. It's very strong – in fact, weight for weight it's tougher than steel – yet also extremely elastic. These two characteristics, together, make for one unique substance in nature that the world's greatest material scientists have been trying to re-create artificially.

Silk is secreted as a liquid from the spider by the spinnerets, which are special glands located in the tip of the arachnid's abdomen. Upon contact with air the liquid instantly hardens to become a fine but strong silk. As the material is produced, the spider pulls it into long, thin threads using its legs.

The reason the spider itself does not become caught in its own web is that, first, it knows which sticky strands to avoid and, second, the adhesive hardens if the unwitting victim makes a sudden movement, but not with the gentle, considered movements of the spider.


© Science Photo Library

Cell count
Tardigrades are eutelic, which means that individuals of the same species all have the same number of cells.

Legs
All tardigrades have eight legs. Their name means 'slow walker'.

Moulting
Some species only defecate when they shed their skin, leaving the faeces behind inside the old skin.

Senses
Some species have very simple, non-image-forming eyes, as well as sensory bristles.

Mouthparts
Tardigrades have a circular mouth that pierces and sucks. Most feed on plants.

Tardigrades

They may be small but are these minibeasts really the toughest creatures on the planet?

Tardigrades are tiny aquatic invertebrates, sometimes called water bears because of the loping way that they move. The largest species are 1.5 millimetres long, the smallest are under 0.1mm. Despite their squishy and vulnerable appearance, they are virtually indestructible. Experiments in laboratories have shown that they can survive pressures of 6,000 atmospheres, temperatures as low as -272°C or as high as 151°C and radiation doses that would most certainly kill us a thousand times over.

They achieve this by dehydrating their own bodies using a special sugar called trehalose, which acts as scaffolding to protect the cell contents. Their water content drops to one per cent of normal in this state and their metabolism slows by 99.99 per cent. Ice can't form in a body this dry and all the chemical reactions that might harm them simply happen too slowly to be dangerous.

ON THE MAP

Tardigrades are everywhere!

1 The top of the Himalayas
2 The bottom of the Mariana Trench in the Pacific Ocean
3 Tropical rainforests
4 The Atacama desert
5 Antarctica, frozen deep in the ice
6 On the moss in your garden

How do water striders walk on water?

The aquatic insect that uses water tension to stay on top

Found in freshwater ponds and still bodies of waters, the water strider, or pond skater, is a predatory aquatic insect that uses the highly sensitive water-repellent hairs on its legs to detect the vibrations of an insect as it falls into the pond. The strider will then race to the location to nab its prey. Despite being denser than water, a water strider doesn't sink; instead it exploits the principle of water tension to stay on the surface.

The forces of attraction between all the molecules in the water pull the molecules at the surface together so that they lock like a thin elastic membrane of slightly denser molecules. The water strider can then cross the surface without sinking.

Water striders have three pairs of legs, the front pair of which are short and dextrous enough to clasp, kill and eat small prey. The middle pair of legs, lying flat on the water, are used as oars to 'row' over the surface while the rear pair act like rudders for steering. Long, splayed legs enable the pond skater to distribute its weight evenly over a greater surface area, further helping it to float.

Dung beetles

The world's strongest insect is a big fan of waste collection

Dung beetles are renowned for their incredible strength and acute sense of smell when collecting the dung of other animals. Most can collect 50 times their own weight, but male onthophagus taurus beetles can push 1,141 times their mass, making them the strongest insect in the world. This is equivalent to a human pulling six double-decker buses full of people.

Male dung beetles developed the strong hind legs required for this feat because they often have to fight off rivals to mate with a female, who waits underground for the delivery of dung from her counterpart. Females lay eggs in dung to provide nutrition and protection for their offspring, who feed on the solid waste. Adult beetles consume only the fluid, which they extract by squeezing the dung in their mouths.

Rolling dung – it's all in a day's work for these guys

© Rafael Brix

TOP 5 FACTS
EXTREME CREATURES
EYES

Eye-spy

1 There are ten eye layouts falling into two categories. Simple eyes have one concave photoreceptive surface, while compound eyes have a number of lenses on a convex surface.

Seven

2 Simple eyes such as those of humans are very common on our planet and have evolved at least seven times from just a small grouping of photosensitive cells.

Mosaic

3 Adult dragonflies can have 30,000 ommatidia, giving them incredibly detailed, mosaic-like images to process. The quantity also grants them excellent movement sensing.

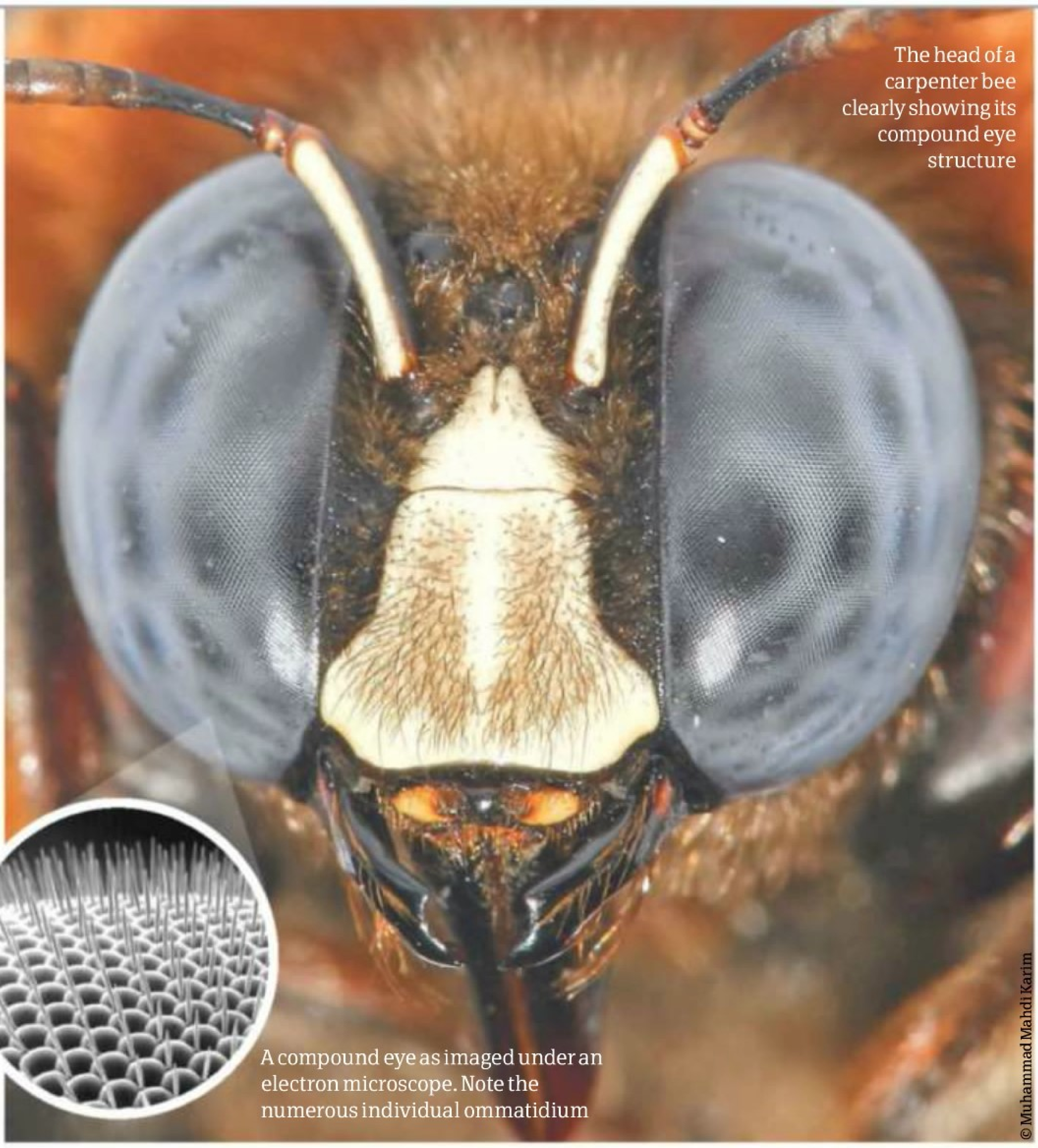
Different forms

4 Compound eyes come in two forms. Apposition eyes work by combining individual points of info together to form an image, while superposition eyes create one whole image.

Cambrian

5 Apposition eyes are almost certainly the original type of compound eye. The oldest eyes found are from the trilobites of the Cambrian Period (542-488.3 million years ago).

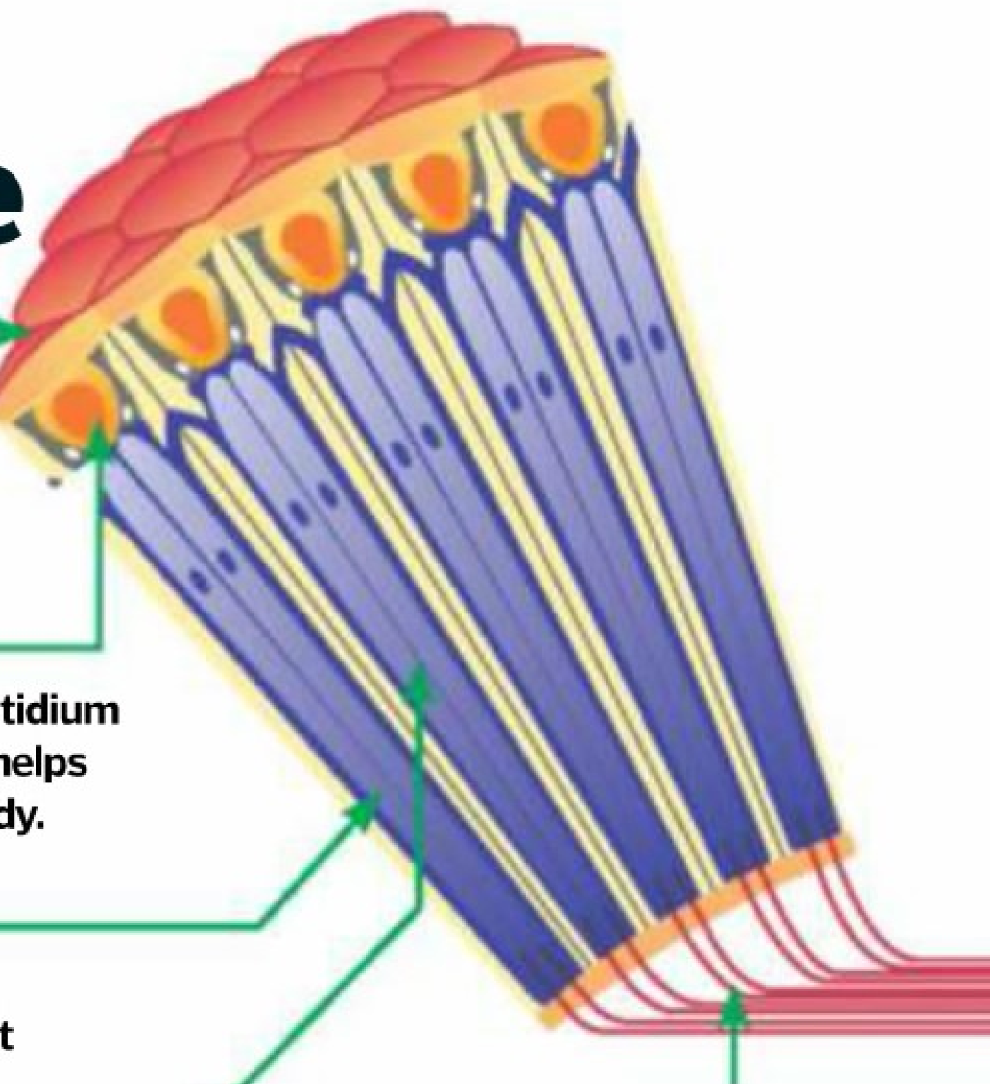
DID YOU KNOW? Thexxxxxxxxxxxxx compound eyes are between 5-50 micrometers in size


The head of a carpenter bee clearly showing its compound eye structure

A compound eye as imaged under an electron microscope. Note the numerous individual ommatidium

© Muhammad Mahdi Karim

Inside a bee's eye



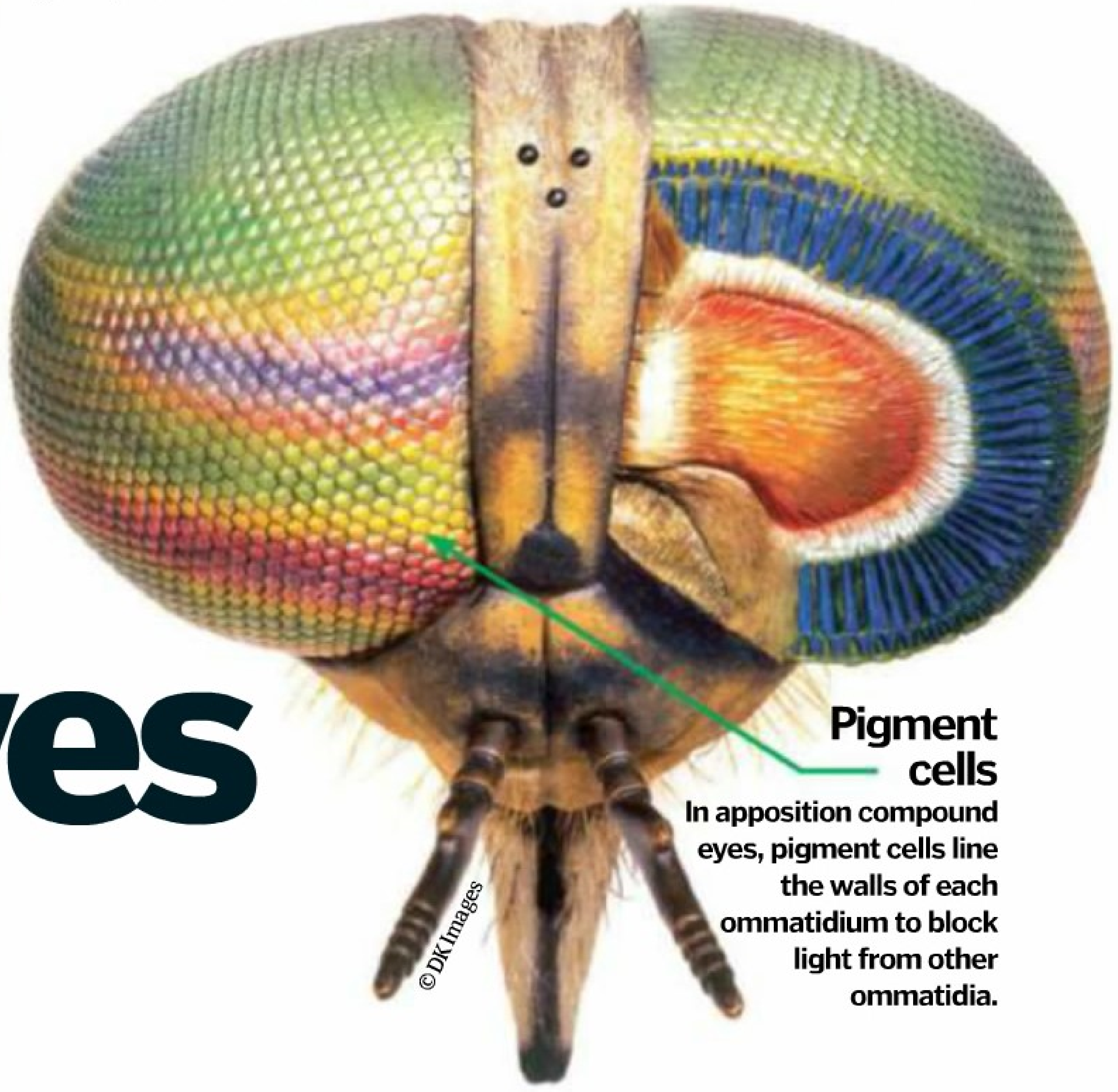
Cornea
The outer part of each ommatidium is overlaid with a transparent cornea that refracts incoming light.

Crystalline cone
Beneath the cornea of the ommatidium is a crystalline pseudocone that helps focus the light further into its body.

Photosensing cells
The inner 90 per cent of the ommatidium contains six to eight long, thin photosensing R cells.

Rhabdom
The portion of the R cells at the central axis of the ommatidium form a light guide, a tube referred to as the rhabdom.

Optic nerve
At the base of the rhabdom it meets an optic nerve which transmits the picture element to the brain.



Pigment cells
In apposition compound eyes, pigment cells line the walls of each ommatidium to block light from other ommatidia.

© DK Images

Compound eyes

Allowing for an incredibly wide viewing angle and the detection of fast movement, compound eyes are highly technical biological structures

Compound eyes are made up of numerous small optical systems arranged around the outside of a convex surface. There are two types of compound eye; apposition and superposition. The former is the more common and works by having each photorecepting system (the eye's ommatidia) independent from every other, each viewing light from just a small part of the overall picture, only to be then pieced together by the brain into a comprehensible whole.

This differs from superposition compound eyes where the individual optical systems do not work separately from each other, but instead pool their light together to produce one single erect image at the back of the eye.

Indeed, apart from an external aesthetic similarity, with an array of facets positioned around a convex structure, the two compound eye types differ greatly in how they work. The main difference is most evident in how the two eyes' ommatidia process light to form an image. In apposition eyes each ommatidium consists of a thin, tapered tube capped with a cornea, beneath which is a transparent crystalline cone through which rays converge to an image at the tip of its receptive structure, referred to as the rhabdom. Each ommatidium is hexagonal in shape and lined with pigment cells, which act as a light barrier between each tube. Because of this, each ommatidium only receives an incredibly narrow proportion of incoming light from directly in front of it, each contributing a small part of the overall picture.

In superposition compound eyes, however, beneath the optical elements there is a wide transparent clear zone, unimpeded by pigment cells. This means that unlike apposition compound eyes where the ommatidium form small isolated images to be pieced together at the brain, the optical elements in superposition eyes superimpose all light rays received across the ommatidia to form one erect image on a deep-lying retina, only then having the whole image sent to the brain for processing.

There are benefits of each type of compound eye, compared to each other and standard lens-bearing eyes as sported by humans. The main benefits include a very large viewing angle – due to the convex array – fast movement tracking due to the amount of photorecepting units that do not have to individually move to track, and the ability to detect the polarisation of light. However, negatively, because the individual elements are so small, due to the principle of diffraction of light, resolution in compound eyes is considerably worse than in normal variants with large lenses (this is why astronomical telescopes have such large lenses or mirrors). The main benefit of superposition eyes over apposition eyes is their ability to deliver a picture in lower light conditions due to the convergence of gathered light rays.

A honeybee collecting pollen from a daisy

© Science Photo Library

Honeybees

Rapidly in decline worldwide, honeybees play a crucial role in sustaining ecosystems. But how do they work?

A prominent member of the apis genus, the western honeybee (apis mellifera) is one of the most valuable insects in the world, producing harvestable beeswax and honey, as well as extensively pollinating a multitude of crops and plants.

As larvae, honeybees emerge from eggs laid by the colony's queen (a large female who is sexually active and controls the hive) into the waxen cellular walls of the hive. They are fed on royal jelly, a goo-like substance excreted from bee glands. Through the consumption of royal jelly the larvae grow into pupae (adolescent grubs) and then, dependent on their lineage and growing environment, turn into one of three adult castes: workers, drones or queens.

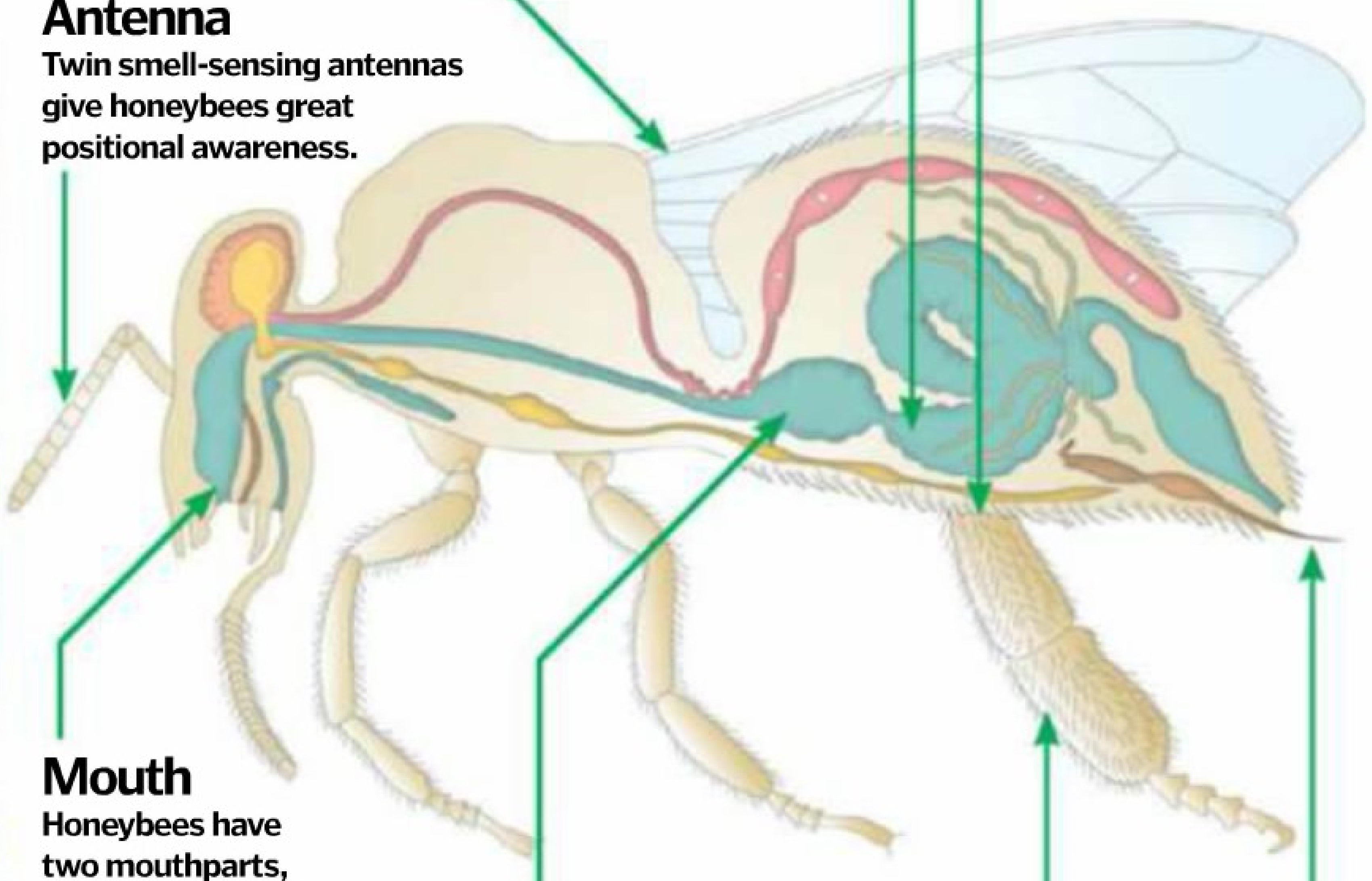
Worker honeybees are the smallest of the three classes and consist of females who did not reach sexual maturity during growth. Equipped with a sting, the workers aid the construction of the hive, and are also responsible for foraging for nectar and pollen, raising young and protecting them if attacked. Drones are larger than workers and are male. Not equipped with a sting, their primary purpose is to mate with the queen, who does so with many of them to ensure the best possible genetic diversity (great for colony strength and health). The queen is the largest class of all and runs the colony. Queens are identified early and fed more royal jelly in order to develop egg-bearing ovaries.

Honeybees produce honey by collecting nectar from plants and crops, a clear viscous liquid made from roughly 80 per cent water and 20 per cent sugar. Once collected by the bees – stored in a special secondary stomach called a crop and taken back to the hive – it is processed by the workers internally using enzymes to break it down into raw honey. This raw honey is then stored by the bees in the combed walls of the hive and capped with a layer of wax. The wax is forced to dry by the drones flapping their wings to create cool air. If the hive is put in threat by fire or predation, the colony will gorge themselves on the reserves before flying off.

Remarkable systems of communication revolve mainly around a series of dances to alert one another to the size, location and distance of food supplies. Most common is the 'waggle dance'. Here, a honeybee that has located a food source returns to the hive before conducting a waggling motion in the source's direction repeatedly, forming a figure of eight. The duration of the movement indicates the distance of the source from the hive.

Since 2006 honeybee colonies have declined rapidly, with some parts of the US and Canada seeing drops of up to 70 per cent. 'Colony collapse disorder' is associated with impaired protein production and is seen to be caused by a combination of severe weather conditions, habitat loss, pesticide usage and various viruses.

Anatomy of a honeybee



Wings
Wings grant the honeybee good flight agility and the ability to cool and set the wax walls of the hive.

Antenna
Twin smell-sensing antennas give honeybees great positional awareness.

Stomach
The primary stomach is used to digest consumed food.

Pollen basket
A polished concavity surrounded by a fringe of hairs, used to carry collected pollen.

Mouth
Honeybees have two mouthparts, one for biting and one for sucking.

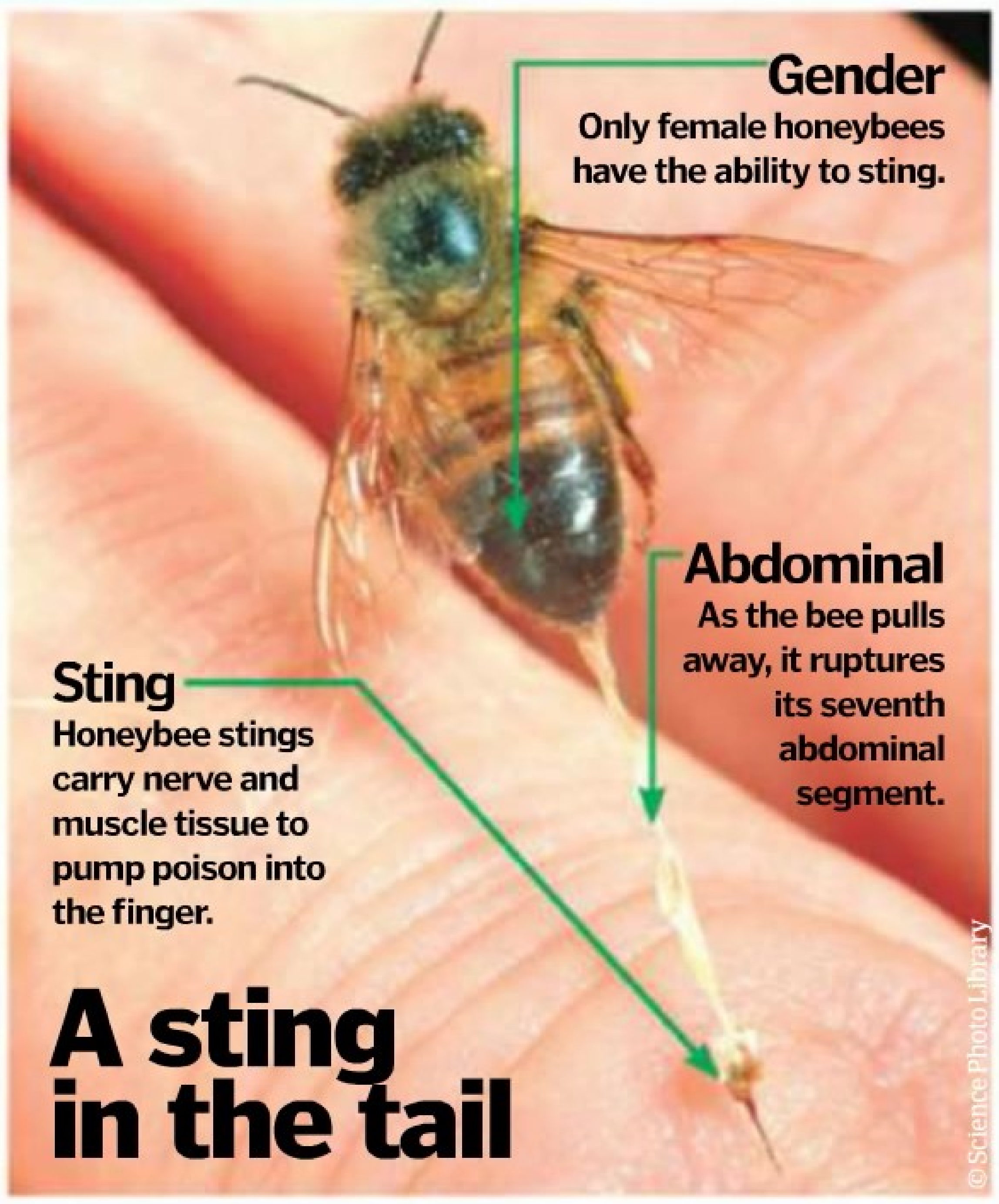
Crop
A smaller internal second stomach sac, where nectar is stored.

Pollen comb
Situated on the honeybee's hind legs, the pollen comb is used to brush and compact collected pollen into the pollen basket.

Ovipositor
The stinger of the bee. Only the female workers and queen have them.

The honeybee's wings offer great control

© Fir0002/Flagstaffotos



A sting in the tail

Gender
Only female honeybees have the ability to sting.

Abdominal
As the bee pulls away, it ruptures its seventh abdominal segment.

Sting
Honeybee stings carry nerve and muscle tissue to pump poison into the finger.

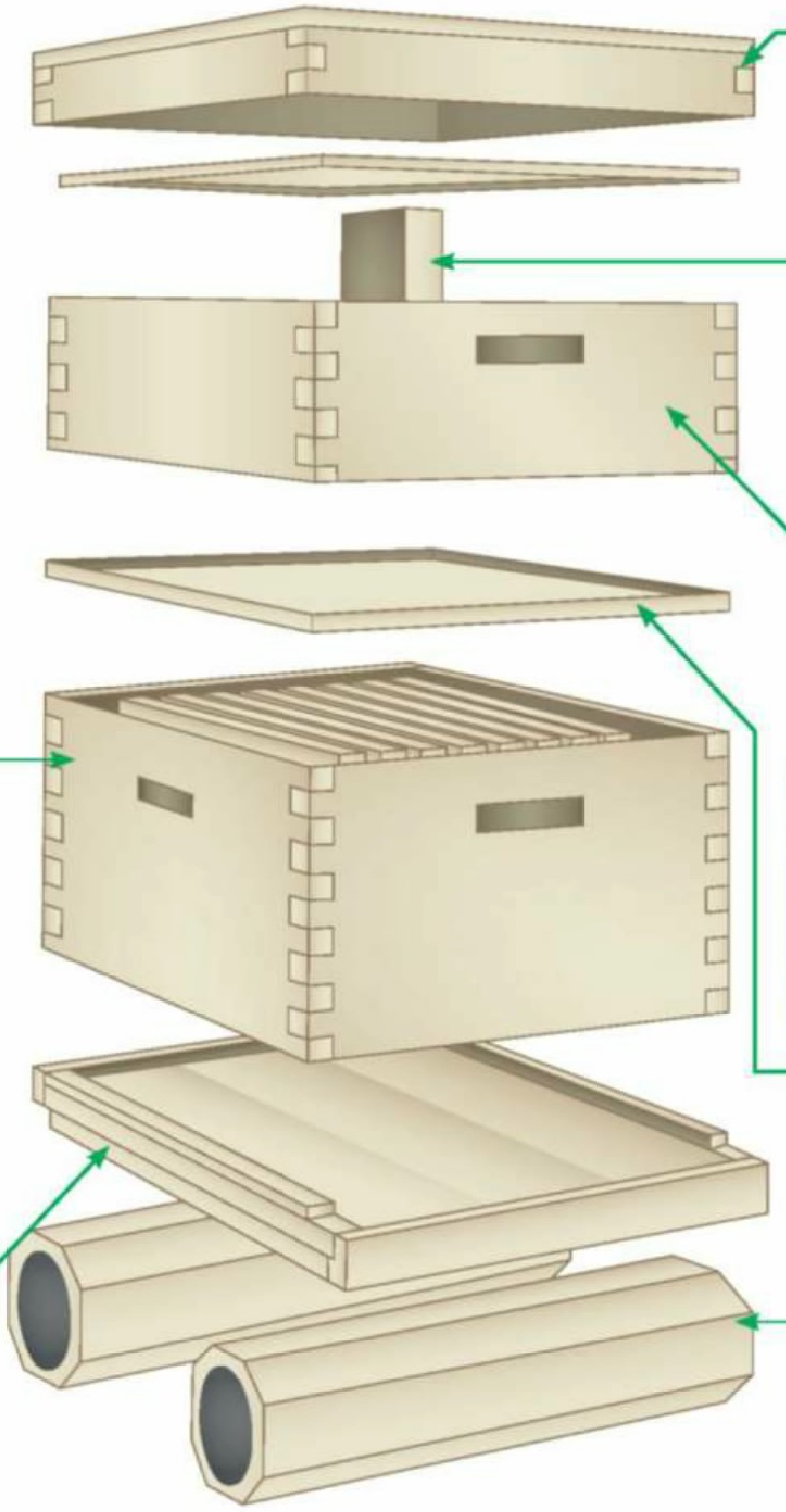
© Science Photo Library

How beehives work

Grab your mask, start your smoke gun and lift out a honeycomb heavy with oozing goodness

Beehive breakdown

The design of a Langstroth beehive has remained nearly unchanged since the American preacher and apiarist invented his artificial hive in 1851. Langstroth's top-opening, stacked hive boxes contain removable frames that are spaced to maximise honeycomb production yet prevent the frames from sticking together with excess propolis, aka 'bee glue'.



Top cover
'Telescoping' top covers hang down over the honey super to stay secure in windy weather. Beekeepers will often prop open the top cover slightly to aid ventilation.

Frames
Each frame is built with a plastic, honeycomb-shaped foundation upon which the bees construct their comb and store their honey. The beekeeper 'decaps' the honeycomb to extract the golden liquid.

Honey super
The honey supers are shallower versions of the hive body with ten removable frames. Since the queen can't reach the honey supers, all of the stored honey in this section will be harvested by the beekeeper.

Hive body
This deep wooden box fitted with ten removable frames is where the queen bee lays her eggs and where the worker bees live, raise their larvae and store their own honey reserves.

© Waugsberg comb 07

Queen excluder
This metal or plastic grill has spaces large enough for worker bees to pass through, but too tight for the queen or drones to fit, preventing the queen from laying eggs in the honey supers.

Bottom board
Made of either solid wood or a metal screen, the bottom section of the hive is also its front door. To keep out mice and other pests, beekeepers sometimes place a cleat across the bottom board opening to restrict its size.

Hive stand
A wooden pallet or even concrete blocks raise the hive ten to 15 centimetres off the ground, separating the hive from moist ground and saving the beekeeper's back.

Beekeeping has always been something of an extreme sport. Ancient apiarists with thick skins would 'rob' wild hives. The Greeks were the first to construct artificial hives out of overturned woven baskets, but the honey harvest was still an uncertain and invariably painful affair.

The modern artificial beehive takes the sting out of beekeeping and ensures an abundant harvest of nature's favourite sweetener. Those stacked wooden boxes on the edge of a farmer's field each contain ten removable frames. The frames hold a thin plastic foundation stamped with a honeycomb pattern and sprayed with a sugar water solution. When a new brood of bees enters the hive, they instinctively build their waxy honeycomb on the pre-stamped patterns, filling the hexagonal cells with the valuable honey. Some of the honey is reserved to feed the bees through the winter and the rest is harvested for your afternoon tea.

The genius of the modern artificial beehive, invented by L L Langstroth in 1851, is that the removable frames are spaced precisely 0.79 centimetres (3/8 inch) apart, the exact width of a worker bee. Given the proper "bee space", honeybees will build a comb that extends far enough from the frame to maximise honey production, but doesn't stick to the adjoining frame. This allows the beekeeper to easily remove and inspect individual frames periodically for comb development and pests.

© Muhammad Mahdi Karim

What is honey?

Honey is a super-concentrated form of nectar, the sugar water produced by flowering plants. The conversion of nectar to honey is the responsibility of worker bees, the female honeybee that forages for nectar and breaks it down into simple sugars using an enzyme in their gut called invertase.

The nectar is then regurgitated into hexagonal wax cells, where other worker bees fan the nectar furiously with their wings until its moisture level drops below 18.5 per cent, officially becoming honey. A single bee produces 1/12th of a teaspoon of honey during its entire lifetime, but the whole hive can generate over 90 kilograms of honey a year.

While wasps have earned something of an unpopular reputation, they are actually invaluable for keeping pests in check

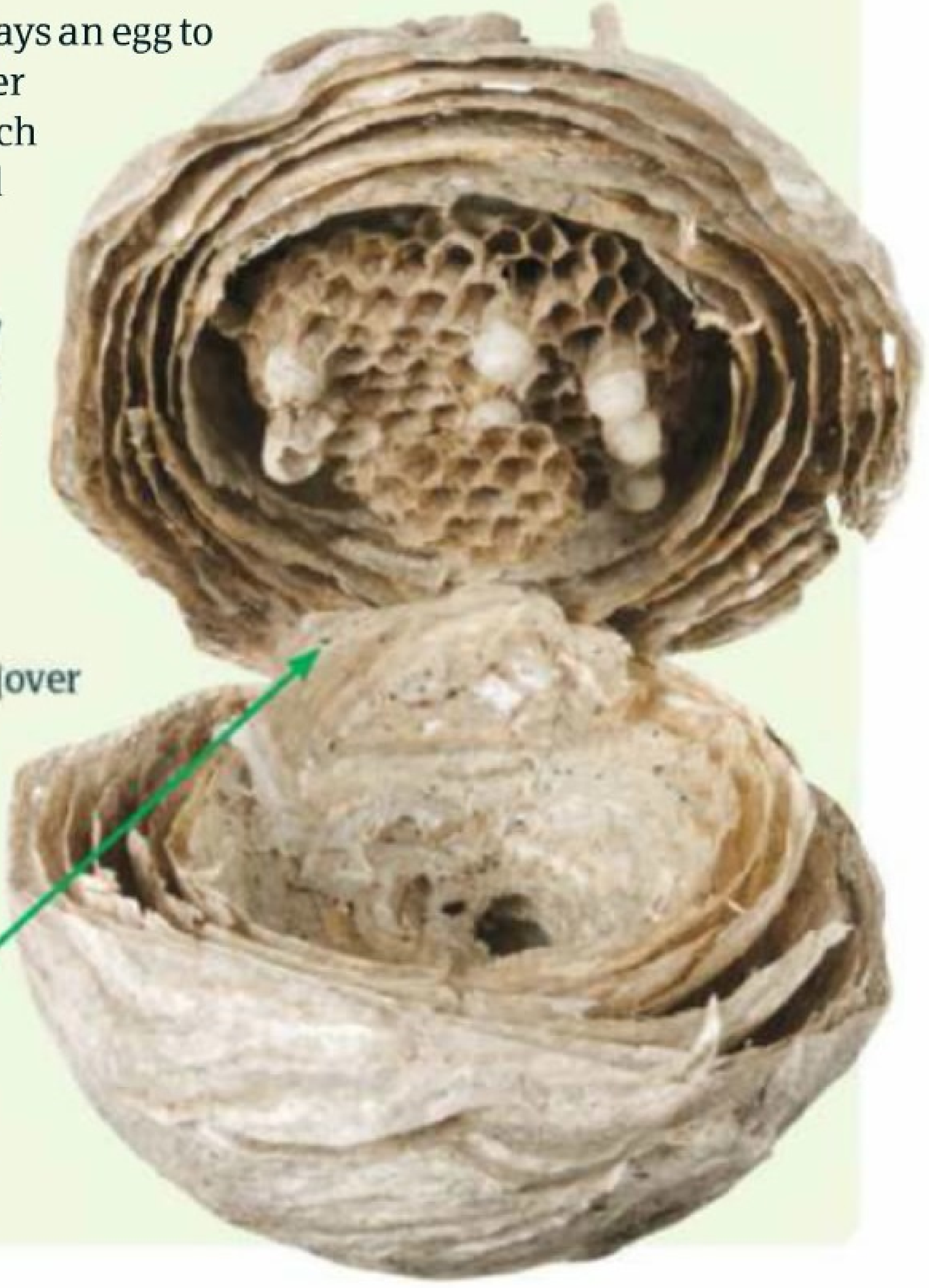
What's inside a wasp nest?

Find out how this predatory insect constructs its papery home

When a queen wasp comes out of hibernation she will begin looking for a site to build a nest. She starts by creating a petiole, which forms the main stalk from which the rest of the nest will hang (like the petiole stalk that attaches a leaf to its stem). To produce the material from which the nest is made wasps collect weathered wood and plant matter with their powerful mandibles and chew it up. The papery matter is combined with saliva to generate a paste ideal for nest construction – even in awkward crevices and cavities, such as a roof's eaves.

The next job for the queen is to begin construction on a small framework of downward-facing hexagonal cells that form the main body, which is used for brood rearing. After building the first cell at the end of the petiole she adds another six around that, and so on until the nest has grown to about the size of a walnut.

Inside each cell the queen lays an egg to create a starter brood of worker females. Eventually these hatch into larvae and the queen will stop nest building to spend about a month looking after these young wasps. Once they are mature enough to fend for themselves, the young wasps then take on the role of workers and resume construction. The world's biggest recorded wasp nest reached a length of 3.7 metres (over 12 feet). With the workers now active, the queen can concentrate on egg-laying and rearing larvae.



Core
The heart of the wasp nest is where not only the structure itself begins, but the colony too, as the queen lays the first of many broods of eggs.

© SPL

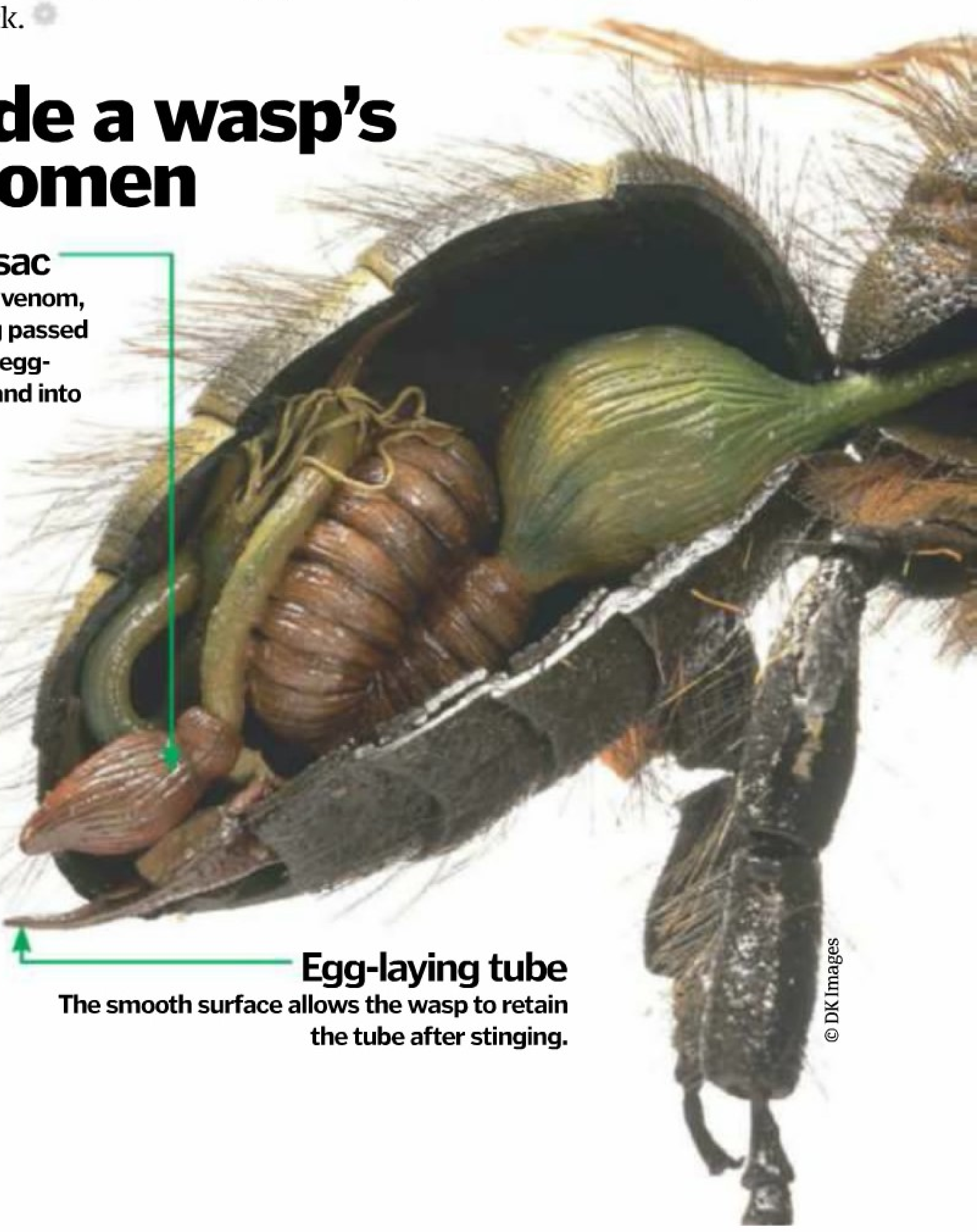
Wasp stings

The wasp holds a potent and reusable form of attack

A wasp stings by transferring venom from an internal venom sac through its egg-laying tube into its victim. The wasp's sting differs from the bee's sting due to the smooth surface of its egg-laying tube, allowing retention of it after an attack for reuse. The bee's jagged equivalent sting however, does not allow for such action, forcing it to literally wrench itself in two and leaving its rear-end and stinger stuck in its victim.

The wasp's sting holds another unique ability. While the venom of a wasp contains many active ingredients, it also carries a pheromone that alarms all other wasps in the area, calling for backup in its attack on its target. This talent is an evolutionary bonus card the bee does not share. Therefore, while bees are more likely to be seen flying in swarms there is greater probability that a sting by a solitary wasp will end up leading to a mass attack.

Inside a wasp's abdomen



Venom sac
Housing the venom, before being passed through the egg-laying tube and into the victim.

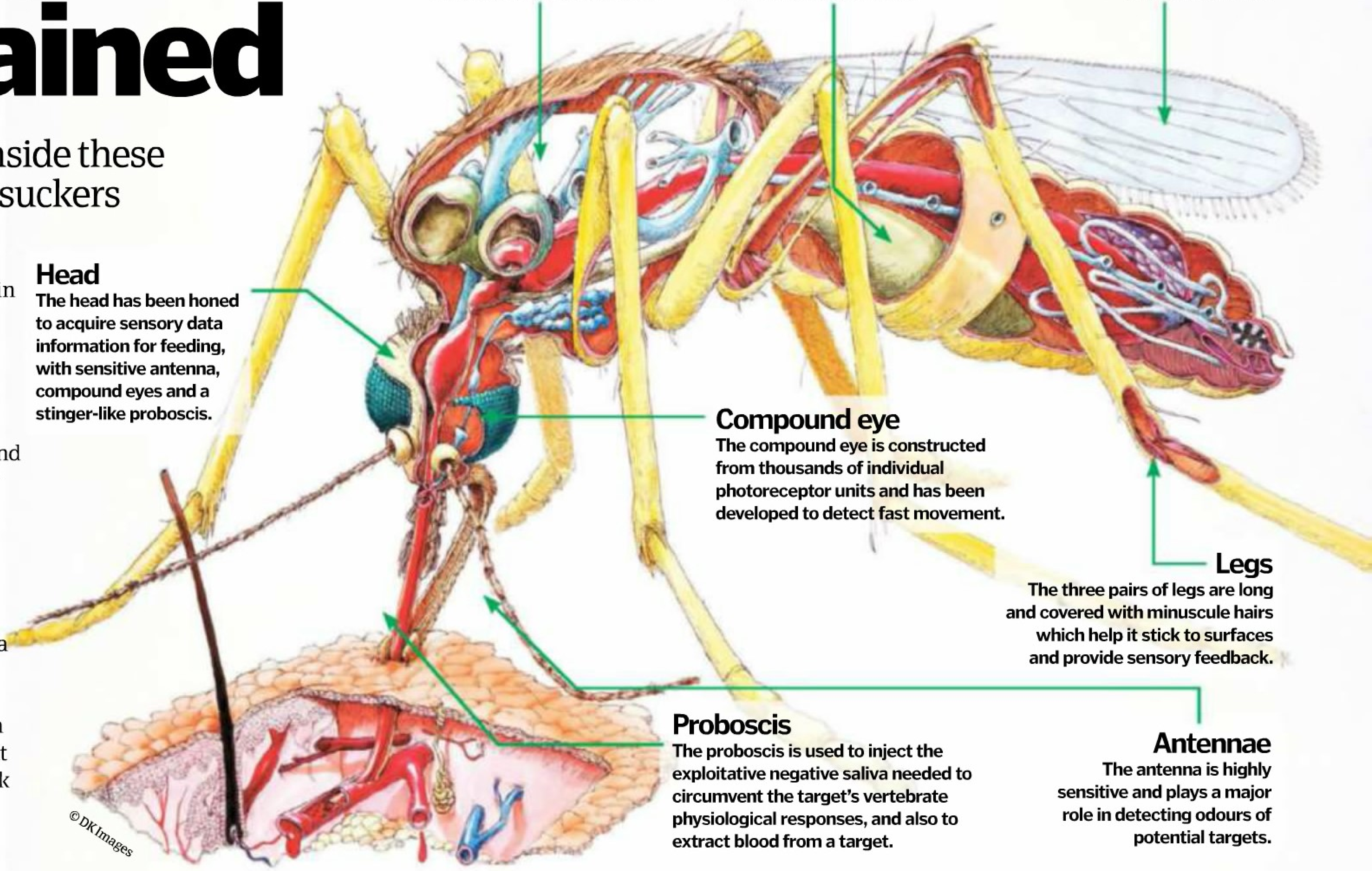
Egg-laying tube
The smooth surface allows the wasp to retain the tube after stinging.

© DK Images

Mosquitoes explained

We take a look inside these miniature bloodsuckers

Mosquitoes are nectar-drinking insects, which – in the case of the females – also drink blood (haematophagy). This is undertaken as the female needs to obtain nutrients there within – such as iron and protein – to help develop her eggs. Vis-à-vis, the common mosquito has developed a highly complex form and system in order to extract these substances from their target host, including a saliva that negatively affects vascular constriction, blood clotting, platelet aggregation and angiogenesis, allowing it to drink freely. We take a look at the mechanisms it has evolved in order to do so.



© DK Images

Thorax
This part of the mosquito is specialised for locomotion, with its three pairs of legs and single set of wings attached.

Abdomen
Comprised of seven segments, blood and nectar are directly sourced here. It is also the digestive area.

Wing
The wings consist of a series of longitudinal and cross veins through a lightweight outgrowth of the exoskeleton.

Head
The head has been honed to acquire sensory data information for feeding, with sensitive antenna, compound eyes and a stinger-like proboscis.

Compound eye
The compound eye is constructed from thousands of individual photoreceptor units and has been developed to detect fast movement.

Legs
The three pairs of legs are long and covered with minuscule hairs which help it stick to surfaces and provide sensory feedback.

Proboscis
The proboscis is used to inject the exploitative negative saliva needed to circumvent the target's vertebrate physiological responses, and also to extract blood from a target.

Antennae
The antenna is highly sensitive and plays a major role in detecting odours of potential targets.

How do fireflies produce light?

Understanding this natural phenomenon

Lampyridae, or fireflies, are not flies at all. This beetle species is celebrated at many cultural festivals for their ability to produce biological lights. They are able to achieve this through a natural heat-resistant substrate enzyme known as luciferase. The cells in the insect's tail produce this enzyme, which chemically reacts with oxygen; the fuel that allows them to produce this natural phenomenon.

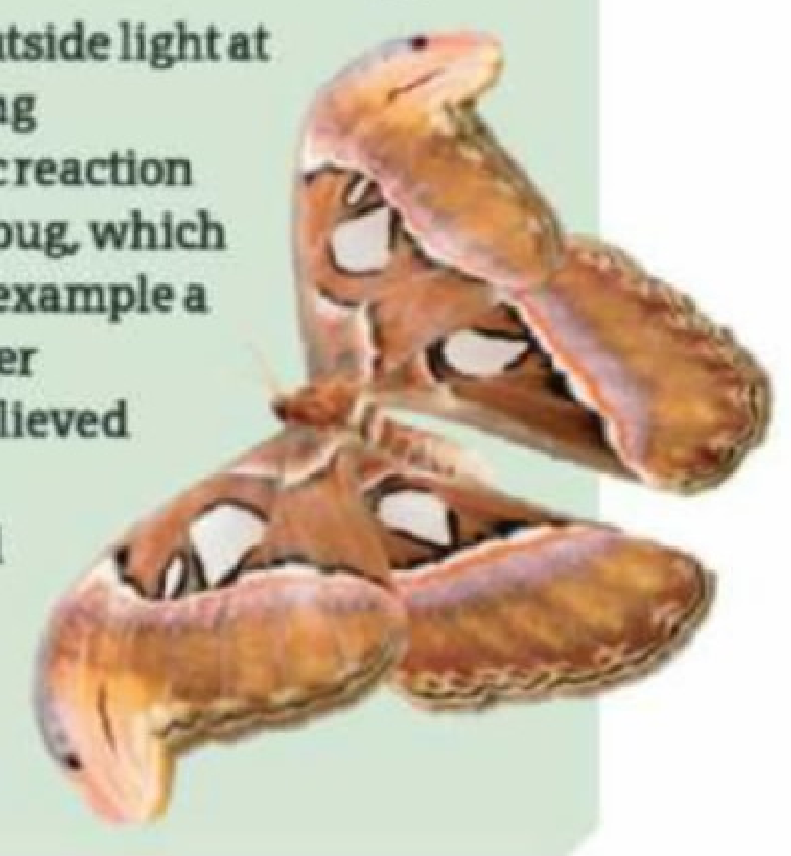
But why do they create light? Fireflies are noted for blinking their lights and the female of the species does this, alternating the rate and wavelength of each flash, to attract fertile males. This is a fundamental interaction, due to the fact that varying species of Lampyridae will occupy the same space. This flashing can distinguish appropriate mates. Firefly larvae are also capable of creating this bioluminescent spectacle, hence the affectionate nickname glowworm.

Image: Art Farmer 2006

Why light attracts moths

Understanding their obsession with light

You're likely to have seen it, a moth fluttering near an outside light at night, spinning around aimlessly. The insect's intriguing behaviour is down to phototaxis, an animal's automatic reaction to or away from light. A moth is a positively phototactic bug, which means it's fascinated and charmed by bright lights, for example a car's headlight, a porch light, or a candle flame. The latter unfortunately doesn't have a happy ending. It is also believed that a moth uses a light at night as a form of navigation. It is mainly the moon that guides a moth, but lamps and other such bright, glowing objects can confuse the creature as it passes by. This sends it in a bit of a dazed and circular pattern around the light, until the Sun comes up when it uses the day to regain its strength.



DID YOU KNOW?

World's largest moth…
Found mainly in southeast Asia, the Atlas moth (or attacus atlas) can have a total wing surface area of 65 square inches and their wingspan can reach up to 12 inches (30cm).

Ladybirds explained

The red-caped heroes of the insect world, ladybirds save the day for gardeners and farmers everywhere

Coccinellids, more commonly known as ladybirds, or ladybugs in North America, are members of the beetle family. There are more than four and a half thousand different species of ladybirds throughout the world living in warm and temperate regions. Though they vary widely in size and colouration, most of us know them as small red beetles with distinctive black spots, a friend of farmers and gardeners.

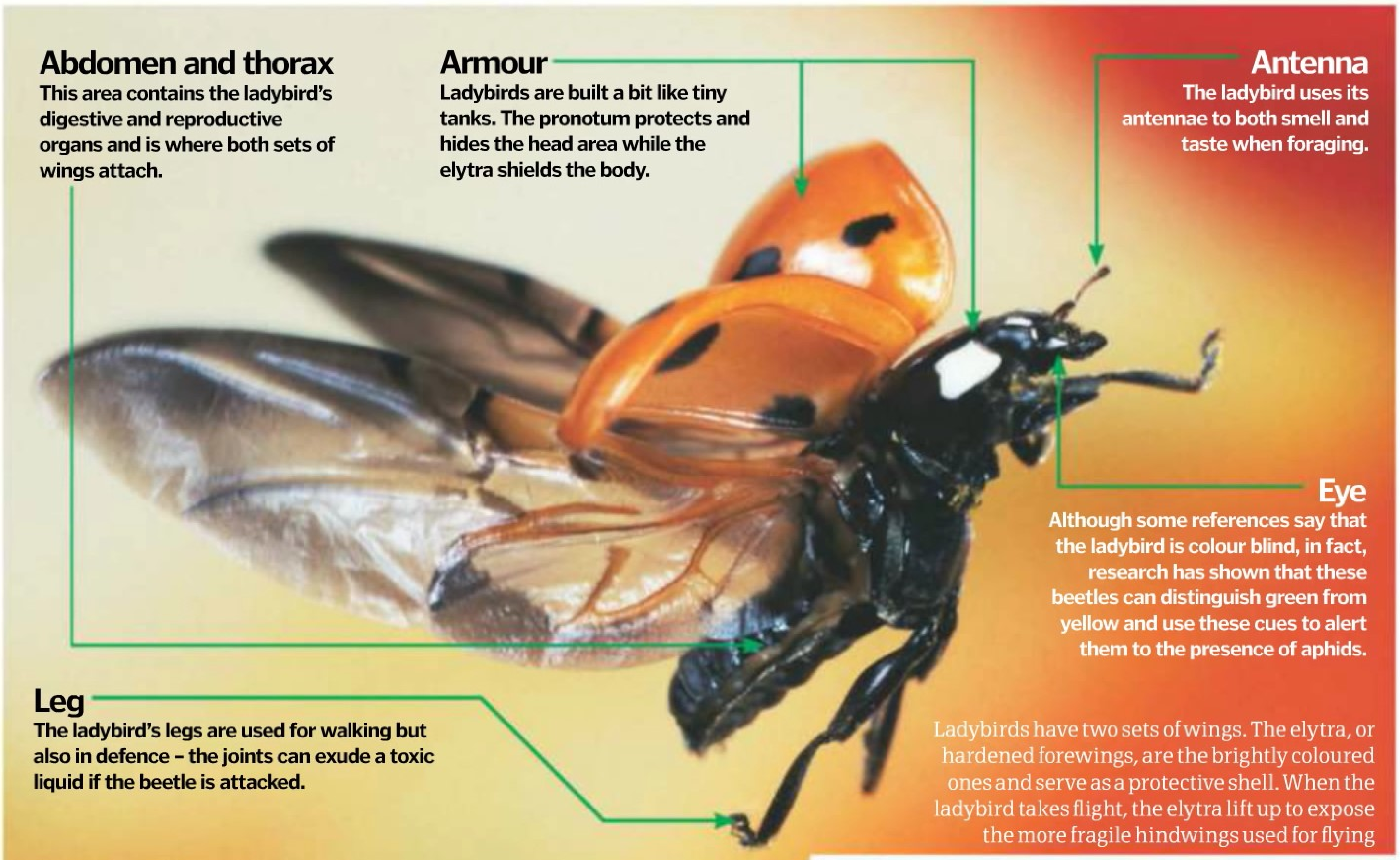
Like all beetles, ladybirds go through a huge metamorphosis on their way to adulthood. Ladybird eggs hatch into larvae, which oddly look a bit like tiny black-and-yellow alligators. These larvae grow and moult, going through several instars, or developmental phases, over a period of two to three weeks, before pupating into adults.

Ladybirds feature aposematic or 'warning' colouration that gives potential predators advanced warning of their bad taste, and when threatened, they can exude a toxic and foul-smelling alkaloid liquid from their joints. In spite of their excellent defence system, ladybirds are not without enemies; parasitic wasps and flies occasionally attack them and some ladybirds fall victim to intrepid spiders and toads too.

Many native ladybird species are under threat from another ladybird species – the Asian or harlequin ladybird (harmonia axyridis). These invaders are generalist feeders and can out-compete resident ladybirds in their native range. They're also somewhat infamous for attempting to hibernate inside human dwellings where they may swarm, stain fabric and even cause allergic reactions.

Currently one-fifth of indigenous British ladybird species are on the decline. In addition to competition with the aforementioned Asian ladybird, climate change and altered land use patterns are likely contributors.

Not all the news is bleak however – a few native ladybirds are expanding their range, and one species – the 13-spot ladybird – previously thought to be extinct has recently been found in Cornwall and Devon.



Abdomen and thorax
This area contains the ladybird's digestive and reproductive organs and is where both sets of wings attach.

Armour
Ladybirds are built a bit like tiny tanks. The pronotum protects and hides the head area while the elytra shields the body.

Antenna
The ladybird uses its antennae to both smell and taste when foraging.

Eye
Although some references say that the ladybird is colour blind, in fact, research has shown that these beetles can distinguish green from yellow and use these cues to alert them to the presence of aphids.

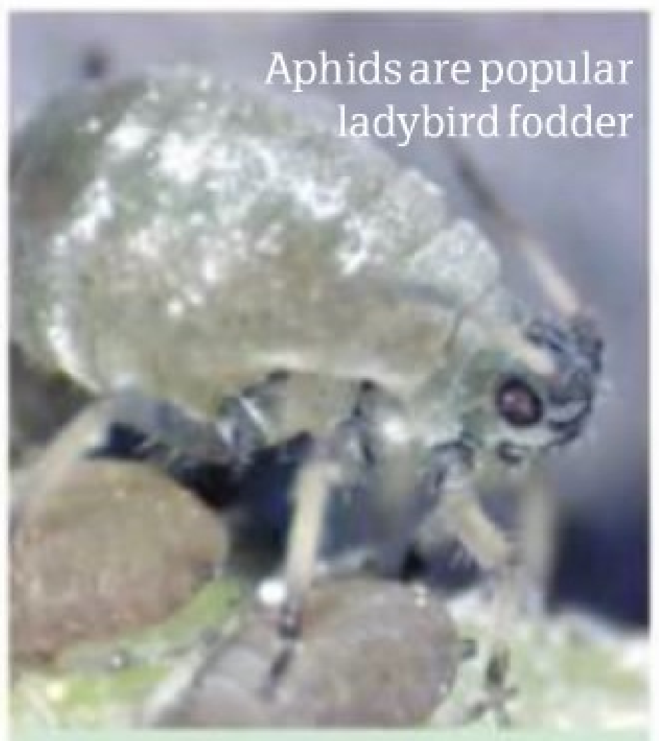
Leg
The ladybird's legs are used for walking but also in defence – the joints can exude a toxic liquid if the beetle is attacked.

Ladybirds have two sets of wings. The elytra, or hardened forewings, are the brightly coloured ones and serve as a protective shell. When the ladybird takes flight, the elytra lift up to expose the more fragile hindwings used for flying

Ladybird anatomy

Although we're most familiar with the jaunty appearance of red-and-black ladybirds, these beetles come in many other colours including yellow, orange and blue. The bright colouration and spots for which ladybirds are known serve as a warning to would-be predators to stay away. Contrary to the popular myth, you cannot tell a ladybird's age by its number of spots, nor are spots an infallible way to distinguish between species.

© SPL



Aphids are popular ladybird fodder

What do ladybirds feed on?

Carnivores and cannibals, ladybirds are justifiably famous (and appreciated) for their habit of eating crop pests. Most ladybird species are carnivorous, consuming soft-bodied insects including aphids, mites, scale insects and white flies. Foraging ladybirds use visual and olfactory clues to home in on food-rich hunting and laying grounds. Newly hatched ladybird larvae have voracious appetites and, if there's insufficient prey available, they may even eat one another! Ladybird mothers also sometimes lay infertile eggs as an additional food source for their young during hard times.

A single ladybird may devour as many as 65 aphids per day. Females consume more than males and both genders eat more when the temperature is warmer, such as in a greenhouse. However, in spite of their reputation, not all ladybird species eat other insects and even the carnivorous species aren't carnivores all the time. Predatory ladybirds rely on pollen, nectar and other plant foods during periods of prey scarcity, and there is a small number of species who spend their lives dining on such delicacies as mildew and fungus.

5 TOP FACTS
DRAGONFLY

H20

1 Female dragonflies lay their eggs on plants next to, in, or on top of water. This is due to the fact that all dragonflies start their life span as water-dwelling nymphs.

Adder

2 In the Welsh language the dragonfly is called 'gwas-y-neidr' ('adder's servant') derived from the fact that dragonflies are often found in the same habitat.

Oding

3 In the US the capturing and studying of dragonflies is referred to as 'oding', a process similar to the more traditional hobbies of birding and butterflying.

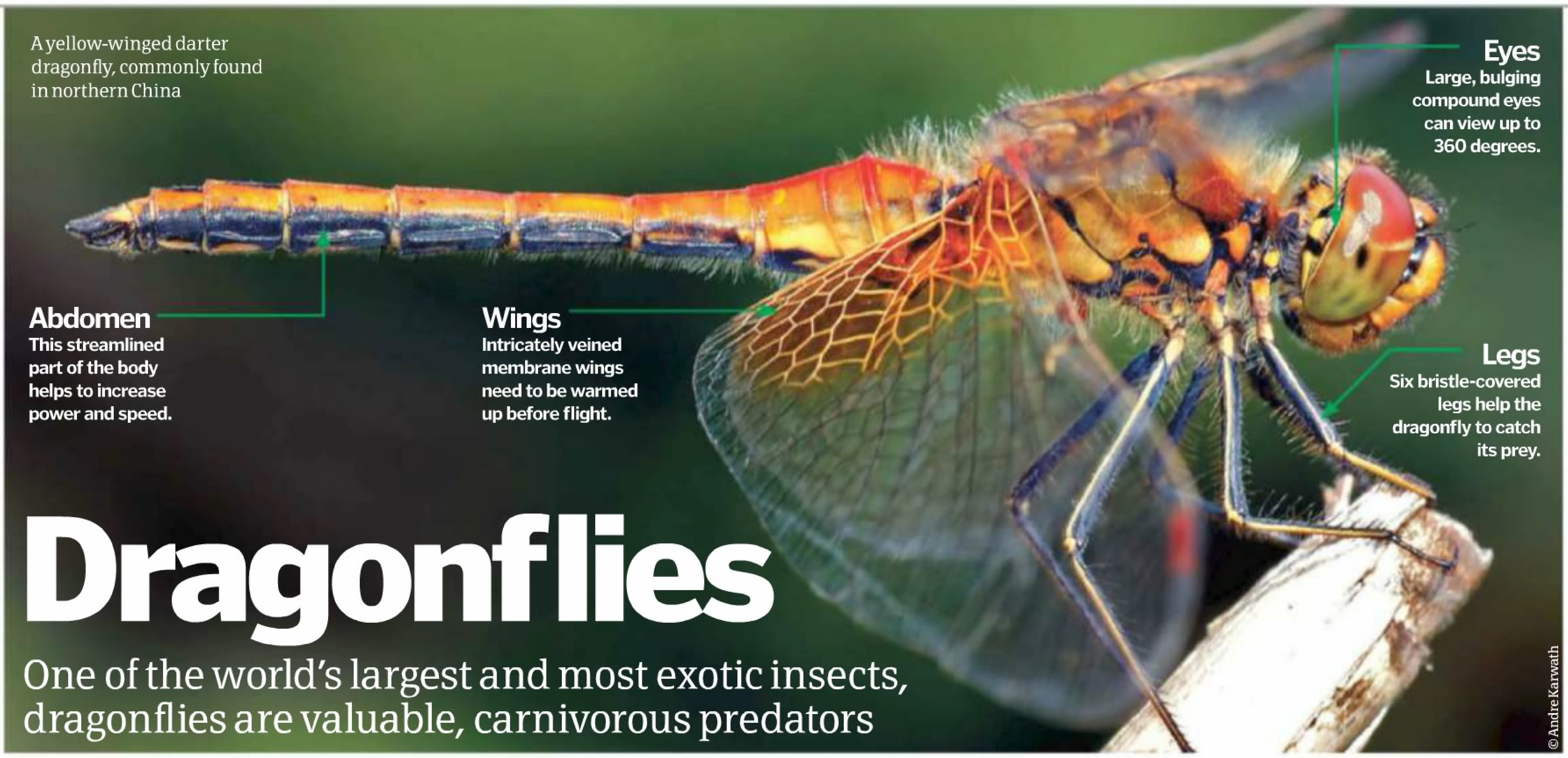
Giant

4 The recorded maximum flight speed of a dragonfly was that of a southern giant darner, at just under 60mph. Typically, however, dragonflies tend to fly between 10-34mph.

Anisoptera

5 The infraorder of dragonflies is Anisoptera. Stemming from the Ancient Greeks, this means 'not equal wings' because their hind wings are broader than their fore wings.

DID YOU KNOW? *Dragonflies can fly at speeds of up to 60mph and have almost 360-degree vision*



A yellow-winged darter dragonfly, commonly found in northern China

Eyes
Large, bulging compound eyes can view up to 360 degrees.

Abdomen
This streamlined part of the body helps to increase power and speed.

Wings
Intricately veined membrane wings need to be warmed up before flight.

Legs
Six bristle-covered legs help the dragonfly to catch its prey.

© Andre Karwath

Dragonflies

One of the world's largest and most exotic insects, dragonflies are valuable, carnivorous predators

Similar to but typically much larger than damselflies, dragonflies are large, agile insects that undertake a valuable role in the Earth's ecosystems, eating mosquitoes and other smaller insects. Their powerful flight abilities stem from their streamlined abdomen and dual sets of intricately veined membrane wings, which allow them to fly at speeds up to 60mph. Dragonfly wingspans range from one inch up to six inches. Their agility also stems from large bulging compound eyes, which on some of the larger species grant them almost 360-degree vision.

Unfortunately, this high performance comes at a cost – dragonfly muscles need to be warm in order to function properly. Therefore, for dragonfly wings to function optimally, the insect has to engage in a series of stationary wing-whirring exercises and elongated periods of basking in the Sun to generate requisite heat before taking off. However, when in flight, the large, warm and toned muscles deliver the dragonfly complete six-way propulsion, moving from a stationary/hovering position directly upwards, downwards, forwards, backwards and left to right.

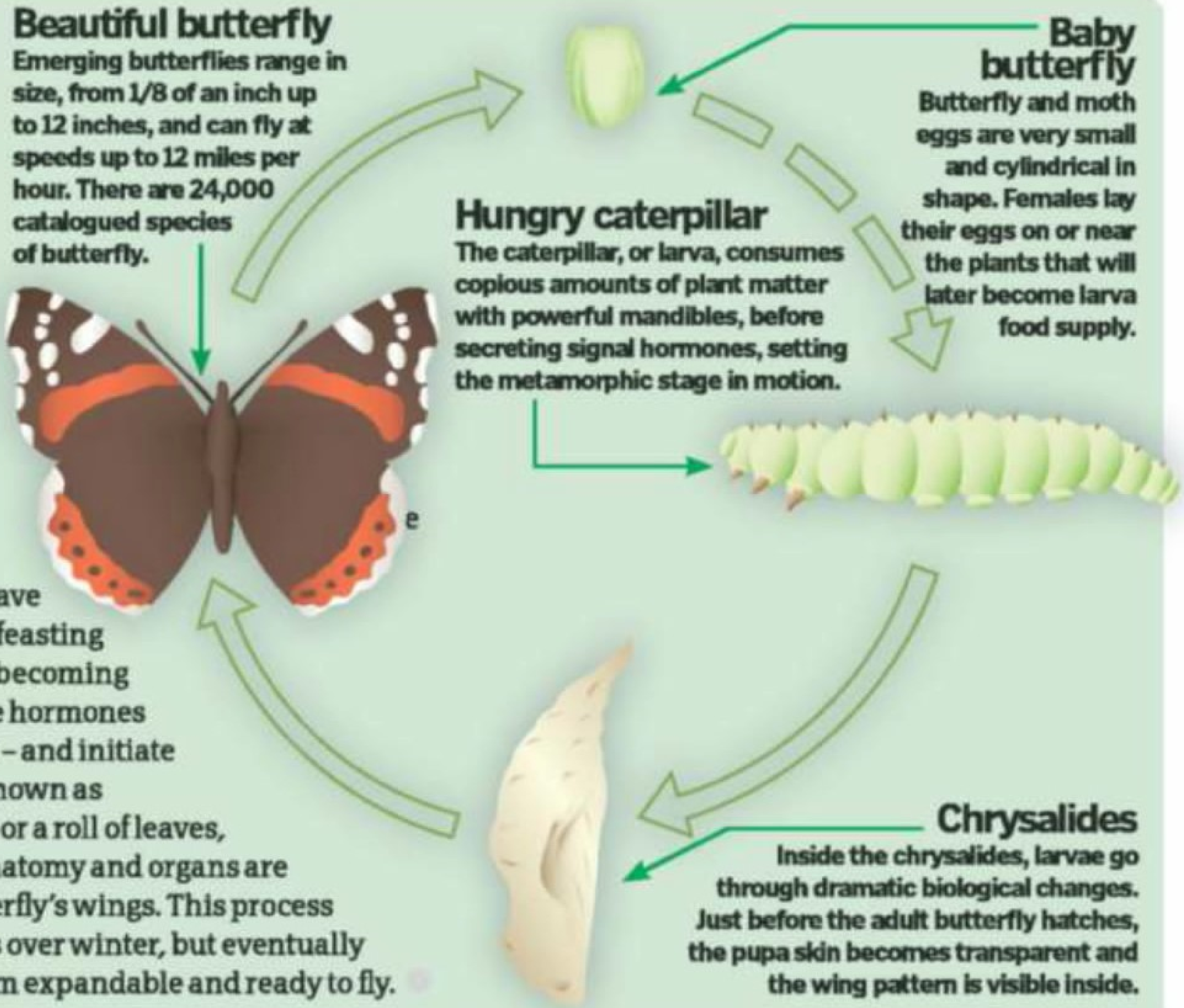
Young dragonflies are called larvae and are aquatic rather than aerial predators. At this stage of their lifespan, they don't possess any wings but sport a formidable anatomical structure not present in adults called the 'mask'. The mask is a disproportionately large structure, to which a set of larger fangs is attached. When not in use, the mask is concealed under the larvae's thorax, extended to capture prey such as tadpoles and aquatic worms. Larvae transform into full-grown dragonflies through a series of moultings, the final one leaving a distinctive exuvia (cast skin) behind.

Metamorphosis

We explore how Lepidoptera metamorphosis takes shape

Belonging to the Lepidoptera family, butterflies are insects that achieve four life stages before turning into all manner of beautiful specimens, including the Hesperiidae, Papilionidae and Nymphalidae. This amazing journey sees Lepidoptera begin life as a plain egg that hatches into a larva, or caterpillar, after a period of six days.

The caterpillar eats constantly for up to four weeks – until pupation – and is adept at consuming plant matter. Using three pairs of true legs and pairs of 'prolegs' – sucker-like structures with hooks on the end – it grips to leaves and plant stems, munching with powerful mandibles. Caterpillars have 4,000 muscles to enable this and a long gut tract to quickly digest food. This feasting fuels tremendous growth and a caterpillar will shed its husk several times, becoming stronger and larger each time. At this stage larvae begin to secrete signature hormones that prompt them to produce a protective silk cocoon – a pupa or chrysalide – and initiate the metamorphic stage. The cocoon, built using modified salivary glands known as spinnerets, may take the form of a small hollow in the earth lined with silk, or a roll of leaves, camouflaged to deter predators. What goes on inside is fascinating: larva anatomy and organs are rapidly dissolving and re-forming into new tissue, limbs and the adult butterfly's wings. This process varies from species to species, some taking no more than two weeks, others over winter, but eventually emerging as a butterfly. Blood is pumped into the insect wings, making them expandable and ready to fly.



Beautiful butterfly
Emerging butterflies range in size, from 1/8 of an inch up to 12 inches, and can fly at speeds up to 12 miles per hour. There are 24,000 catalogued species of butterfly.

Baby butterfly
Butterfly and moth eggs are very small and cylindrical in shape. Females lay their eggs on or near the plants that will later become larva food supply.

Hungry caterpillar
The caterpillar, or larva, consumes copious amounts of plant matter with powerful mandibles, before secreting signal hormones, setting the metamorphic stage in motion.

Chrysalides
Inside the chrysalides, larvae go through dramatic biological changes. Just before the adult butterfly hatches, the pupa skin becomes transparent and the wing pattern is visible inside.

Attack of the giant insects

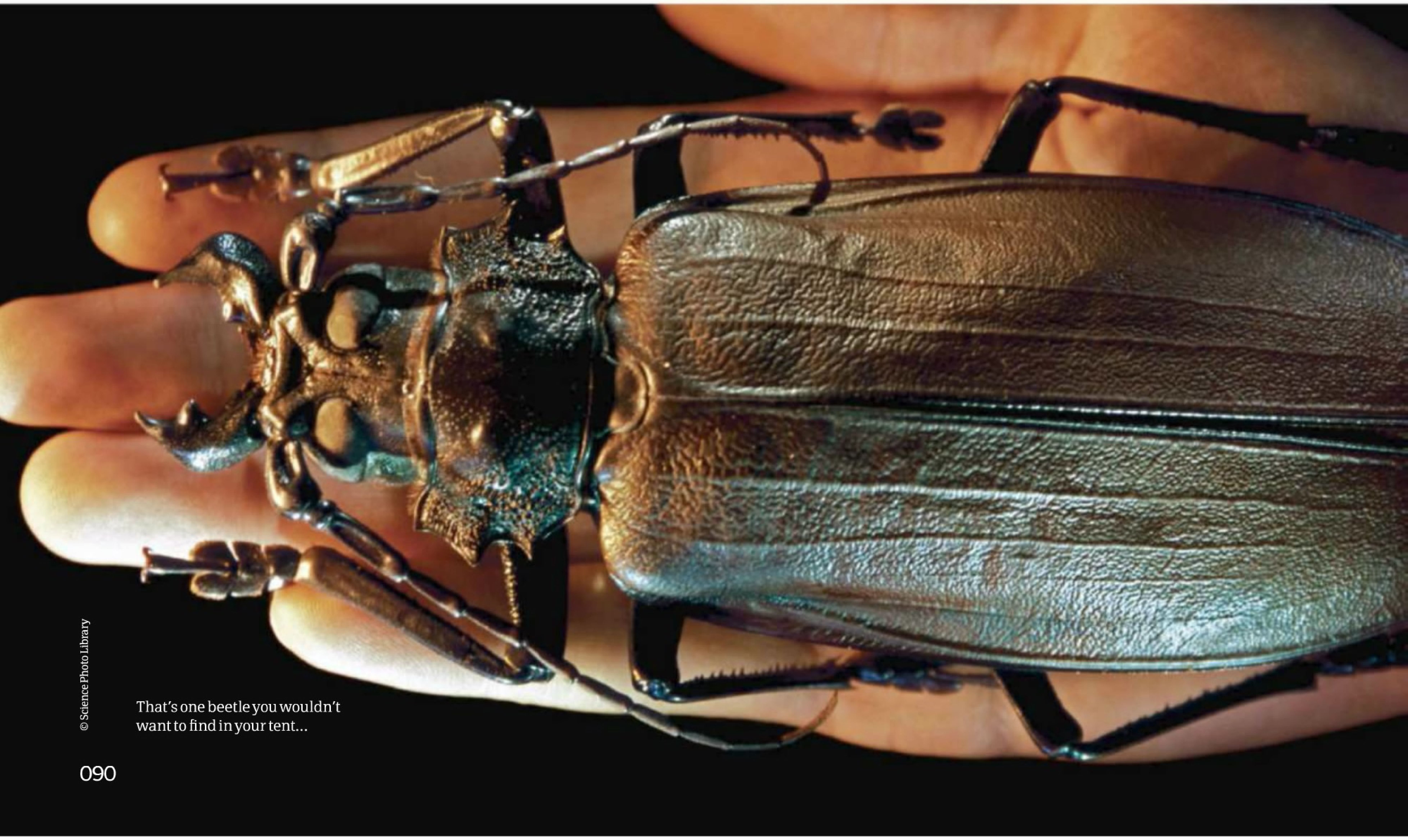
Massive moths, colossal crickets and blooming big beetles – the supersized bugs are here…

Insects are the most successful animal class on the planet. They show the greatest diversity in shape and size and can be found in every land habitat. Around 90 per cent of all animal species are insects; the beetles alone represent one fifth of all known species. Despite this incredible variation, all insects are built from the same basic body plan. Insects are arthropods – the group of animals that includes arachnids like spiders and also contains crustaceans.

The basic arthropod design has an exoskeleton divided into segments, with one pair of legs on each segment. Some arthropods – such as millipedes – stick quite closely to this primitive plan. Others specialise by fusing segments or modifying legs for other uses. The word 'insect' means 'cut into three', and the distinguishing feature of this class is that the body segments have been fused and organised into three different parts: head, thorax and abdomen. The head has legs modified to form mandibles, pincers and antennae, the abdomen may have a stinger, spinnerets or ovipositor (egg-laying organ) at the end, but is otherwise clear of limbs. Only the central thorax has legs. All insects have three pairs of legs and most have two pairs of wings, though in many orders, one or both pairs of wings may be modified or absent.

Insects provide us with honey and silk and they have a huge impact on agriculture. The herbivorous insects are often major pests of crops, but the carnivorous insects, such as wasps and ladybirds, eat the herbivores and keep the populations under control. Insects, especially bees, are also crucial for pollinating flowering plants. One in every three bites of food that you eat relies on insect pollinators for its production.

Most insects are quite small and go largely unnoticed. A square mile of empty field contains more insects than there are humans in the world. Insect size is limited by several factors. An exoskeleton quickly becomes too heavy to support its own weight as size increases, and since they are cold-blooded, their metabolic rate depends on



That's one beetle you wouldn't want to find in your tent…

© Science Photo Library

5 TOP FACTS
BIG BUG FACTS

Most expensive
1 The Queen Alexandra's Birdwing is the largest butterfly in the world. It is also one of the most expensive. Specimens have sold for $12,400 (£7,600).

Most refreshing
2 The jungle nymph stick insect is one of the heaviest insects in existence. In Malaysia they are fed guava leaves and the droppings are used to make tea.

Longest
3 Chan's megastick (phobaeticus chani) is the longest insect in the world; one specimen is 56.7cm (22 inches) long. It was only discovered in 2008.

Most dangerous
4 The Asian giant hornet is the largest wasp in the world. Its sting kills more people in Japan each year than all other wild animals combined, including bears and snakes.

Largest actual bug
5 True bugs belong to the order hemiptera and have piercing and sucking mouthparts. The largest is the giant water bug, which can be 10cm (four inches) long.

DID YOU KNOW? *Cockroaches aren't radiation-proof; just 6-15 times the lethal dose for humans will kill them*

the temperature of the environment.

However, in tropical climates, a few species have reached sizes of 15cm long or more. At this size, insects are restricted by how much oxygen they can get to their organs. Insects don't have lungs; they rely on a network of tubes connected to openings called 'spiracles' that run down the side of the abdomen. Insects can pulse their abdomen and flap their wings to ventilate the spiracles, but as the insect gets bigger the proportion of the body that is taken up by spiracles gets rapidly out of hand.

Oxygen comprises 21 per cent of our planet's atmosphere and the largest insects today are only the size of the smallest mammals. However, during the carboniferous period 350 million years ago, oxygen levels rose as high as 35 per cent. This, combined with the fact that mammal predators hadn't evolved yet, drove some species to become enormous. Dragonfly-like insects the size of seagulls and a 2.6m millipede called arthropleura lived at this time. The current record holders are a little more modest, but you still wouldn't want to find any of these inside your bed! Let's see how these not-so-little critters measure up...

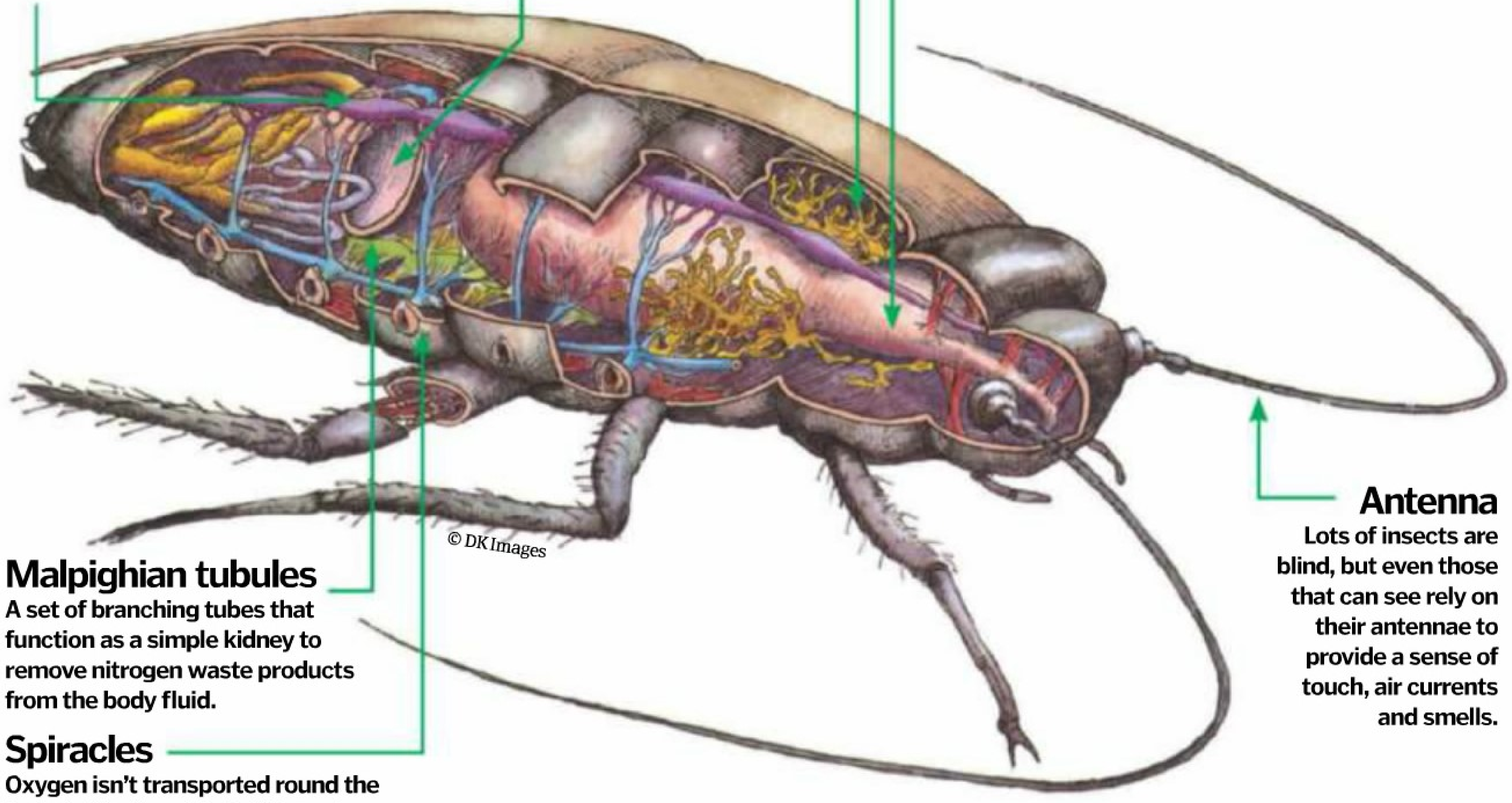
Inside an insect

Heart
Insect blood sloshes loose inside the body cavity. The heart is an open-ended tube that stirs this blood, like squeezing a washing-up liquid bottle in the bath.

Ovary
Most adult insects are just mating machines. Termite queens can lay 2,000 eggs a day, but most insects lay 50-300 in their lifetime.

Nerves
Insects only have space for tiny brains with hard-wired responses to external stimuli. Their wing muscles can contract with each nerve impulse, to allow for faster wingbeats.

Digestive tract
Many insects either drink easily digestible foods like plant sap or else regurgitate enzymes onto their food and then lap up the resulting soup.


© DK Images

Malpighian tubules
A set of branching tubes that function as a simple kidney to remove nitrogen waste products from the body fluid.

Spiracles
Oxygen isn't transported round the body in the blood, but diffuses in through the spiracles and along a network of tubes called tracheae.

Antenna
Lots of insects are blind, but even those that can see rely on their antennae to provide a sense of touch, air currents and smells.

The statistics...

Titan beetle

Size: 167 x 66mm (6.5 x 2.6in)

Weight: 80g

Diet: None

Average life span in the wild: Unknown, probably several years

As big as: Your hand

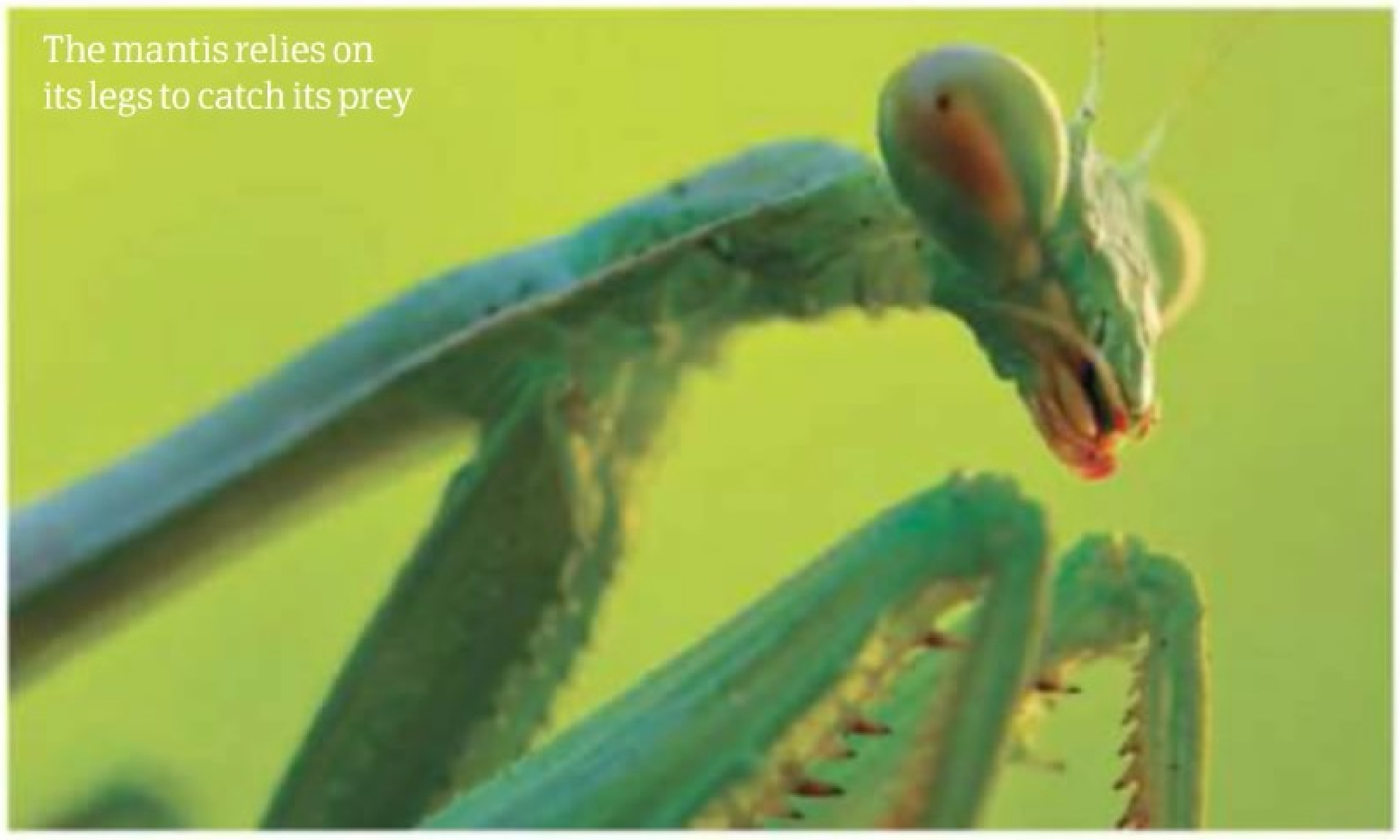
THE WORLD'S LONGEST BEETLE

Titan beetle

Titanus giganteus

When you're as large as the titan beetle, your armoured carapace is thick enough to protect you from any insect predator. But now you represent a large enough meal to attract much larger carnivores, you'd better be ready to defend yourself.

As well as its spiky thorax, the titan beetle has mandibles that are said to be capable of snapping pencils and slicing flesh. Despite its large size, the titan beetle can still fly. It can't take off from the ground, so it uses its claws to climb trees for a gliding start. Adults don't eat at all – their mandibles are purely for self-defence and they spend their lives searching for mates. The larval form has never been found, but probably lives in rotting wood and may be as much as 30cm long and 5cm wide.


The mantis relies on its legs to catch its prey

In the forests of the carboniferous period, the Earth was inhabited by huge insects and other invertebrates

© Science Photo Library

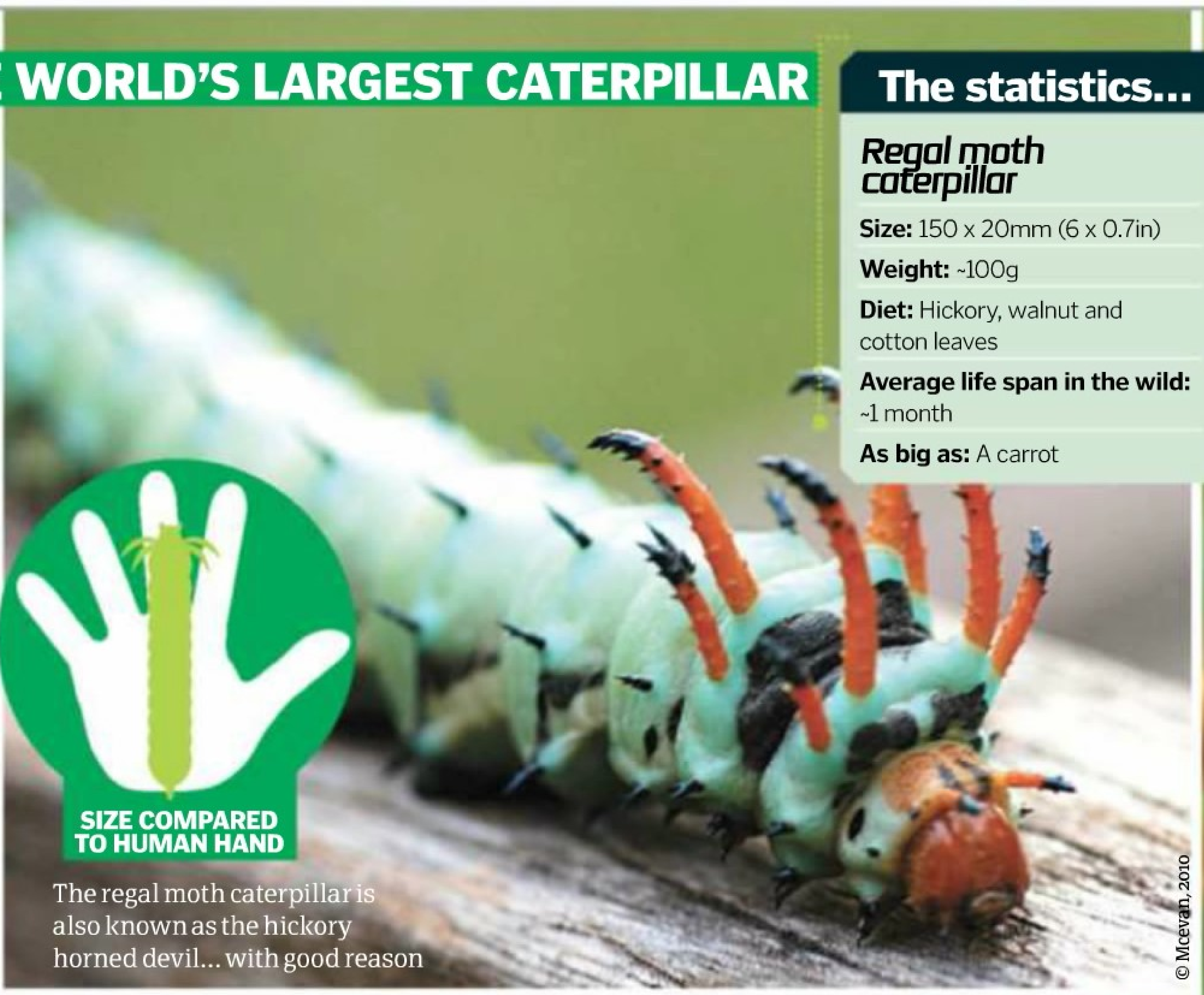
THE WORLD'S LARGEST CATERPILLAR

Regal moth caterpillar

Citheronia regalis

It's absolutely huge, brightly coloured and covered in spikes, but the regal moth caterpillar is quite harmless. There are no poisonous spines or hairs, and the 'horns' are actually just soft appendages to scare off predators. Regal moth caterpillars hatch from eggs just 2mm across, laid in groups of no more than four on the top surface leaves from any of several different tree species. They are a solitary species, which is just as well, because a single caterpillar can strip several branches completely bare.

The caterpillars moult five times during their life, to make room for their growing bodies. The smaller stages, or instars, feed at night and resemble bird droppings to discourage birds. Only the last instar has the bright colours and the horns, and at this point the caterpillar is hungry enough and scary-looking enough to eat round the clock. The adult regal moth lives just a few weeks.


SIZE COMPARED TO HUMAN HAND

The regal moth caterpillar is also known as the hickory horned devil… with good reason

© Mcevan, 2010

The statistics…

Regal moth caterpillar

Size: 150 x 20mm (6 x 0.7in)

Weight: ~100g

Diet: Hickory, walnut and cotton leaves

Average life span in the wild: ~1 month

As big as: A carrot

It's not called the 'giant weta' for nothing…

© Science Photo Library

THE WORLD'S LARGEST PRAYING MANTIS

The statistics…

Chinese mantis

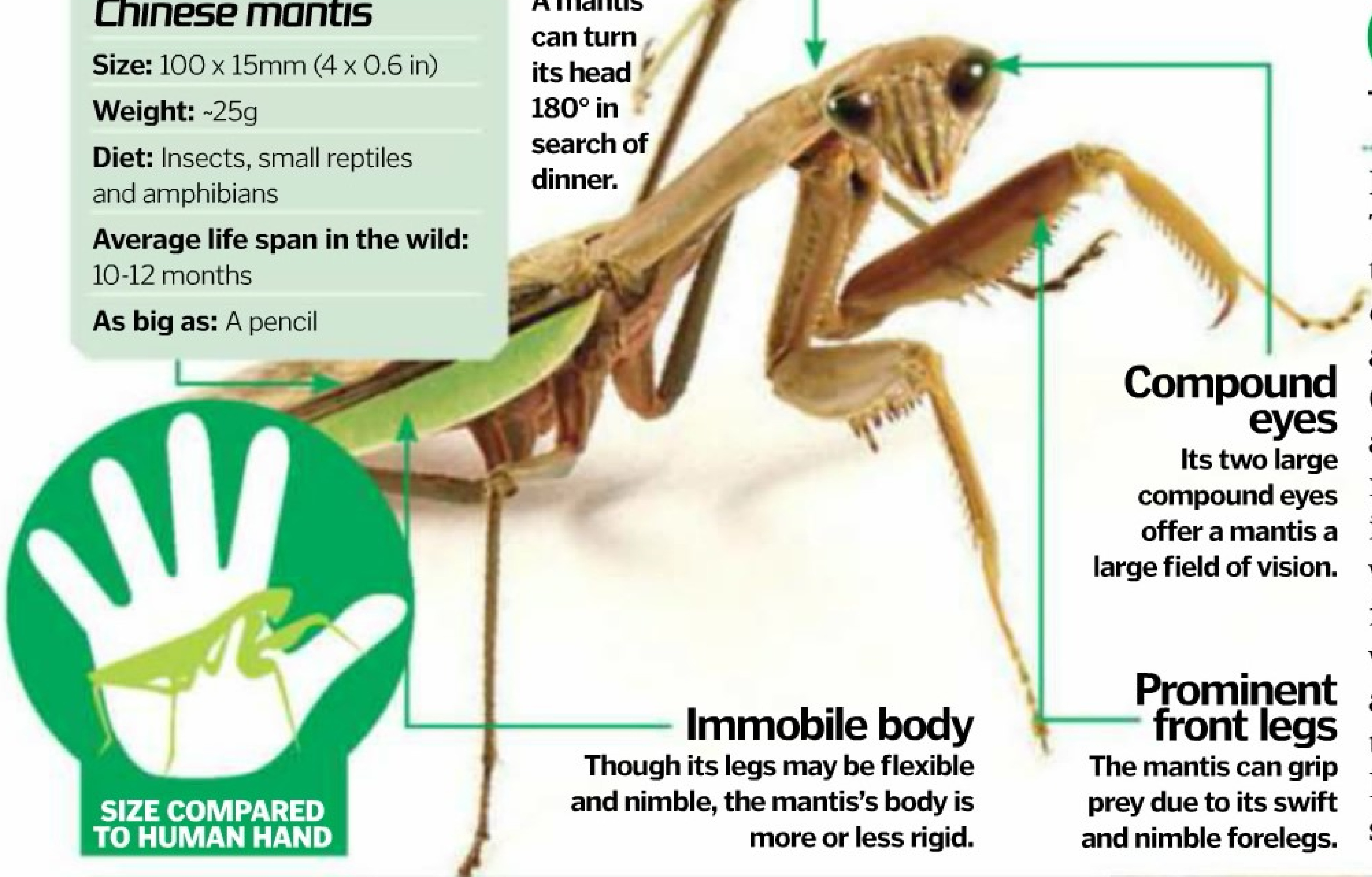
Size: 100 x 15mm (4 x 0.6 in)

Weight: ~25g

Diet: Insects, small reptiles and amphibians

Average life span in the wild: 10-12 months

As big as: A pencil


SIZE COMPARED TO HUMAN HAND

Head turner
A mantis can turn its head 180° in search of dinner.

Compound eyes
Its two large compound eyes offer a mantis a large field of vision.

Immobile body
Though its legs may be flexible and nimble, the mantis's body is more or less rigid.

Prominent front legs
The mantis can grip prey due to its swift and nimble forelegs.

Chinese mantis

Tenodera sinensis

Mantises are voracious predators. The Chinese mantis is large enough to take on virtually any insect, and even small frogs and lizards. There are several documented cases of Chinese mantises catching, killing and eating hummingbirds. The mantis has no venom and relies instead on lightning-fast strikes with its folded forelegs. These have a forward-facing spike on the end, which is used to impale the prey, and rearward-facing spines lining the inside surface of the longest two leg segments. The legs create a serrated scissor grip that will hold struggling animals in place, so that the mantis can feed. The Chinese mantis doesn't seem too concerned with making sure its prey is dead before it tucks in. Once those powerful front legs have slammed shut, it is very difficult for even large prey to escape. The species was introduced to North America around 1895 to control insect pests, and is now fairly common in the north-eastern United States.

The statistics…

Goliath beetle

Size: 110 x 55mm (4 x 2in)

Weight: 100g

Diet: Tree sap and fruit

Average life span in the wild: ~1 year

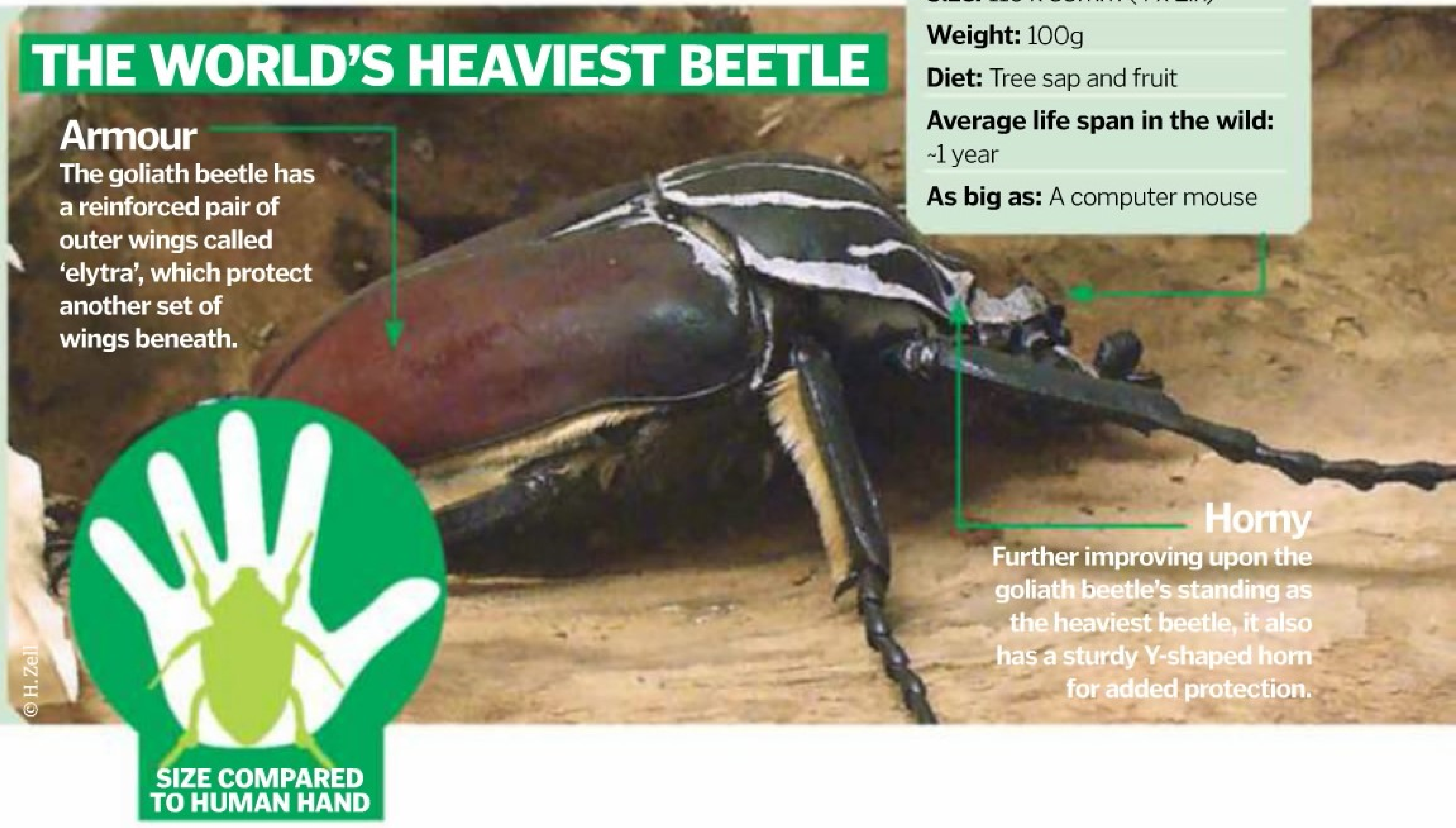
As big as: A computer mouse

Goliath beetle

Goliathus

There are six known species of goliath beetle, all of them truly massive. The larvae live in decaying leaves and wood on the forest floor, but they need more protein than other beetle larvae and will also eat insects and carrion (decaying animal flesh). When they reach full size, the larvae build a cell out of hardened soil to protect themselves while they pupate. Once the adult beetle emerges from the pupa, it stays inside the cell, hibernating until its carapace has hardened and the dry season ends. The first rains wash away the cell walls and the beetle emerges. Just like the titan beetle, the adult goliath beetle spends its time looking for a mate, but has working mouthparts and can sustain itself with sugar-rich foods, so can live for as long as a year.

THE WORLD'S HEAVIEST BEETLE


SIZE COMPARED TO HUMAN HAND

© H. Zell

Armour
The goliath beetle has a reinforced pair of outer wings called 'elytra', which protect another set of wings beneath.

Horny
Further improving upon the goliath beetle's standing as the heaviest beetle, it also has a sturdy Y-shaped horn for added protection.

Head to Head
Natural wonders

© Luc Viatour

1. Orchid mantis

Over the course of several moults, the orchid mantis's body shape and colour change to match, as it waits for prey to visit.

2. Hercules beetle

The Hercules beetle grows to over 15cm (six inches) in length and can support 850 times its own weight on its shell.

3. Puss caterpillar

The fluffiest insects in the world are the larvae of the megalopygidae moth. Those hairs are highly venomous though, so no touching!

DID YOU KNOW? *The Malaysian giant stick insect hatches from an egg just 4mm across, but uncurls to 700mm long!*

THE WORLD'S LARGEST CRICKET

Giant weta

Deinacrida

New Zealand had no mammals until they were introduced by western settlers. Instead, many insects evolved to fill the same ecological niches that are occupied by small rodents elsewhere. In a sense, the native species weta fulfils the same role as a mouse. Without mammal predators, weta have already evolved to be quite large compared with other temperate insects, but the giant weta is found on the small islands off the coast of the main New Zealand islands. Small islands tend not to support large predators (such as the owls that hunt other weta on the mainland), and so the weta there have evolved into larger species. Giant weta can bite but they aren't venomous, and their primary defence is from the spines on their hind legs. When threatened, they scrape their legs against the side of their abdomen to make a warning hissing sound and slash with the hind legs.

The statistics...

Giant weta

Size: 100 x 20mm (4 x 0.7in)

Weight: 50g

Diet: Plants and insects

Average life span in the wild: 2 years

As big as: A sparrow

The weta has been stalking the Earth since prehistoric times

THE WORLD'S LARGEST MOTH

Atlas moth

Attacus atlas

Measured by wing surface area, the atlas moth is the largest in the world. Their huge size makes them very unsteady fliers and when the females emerge from the cocoon, they simply hang there, broadcasting pheromones into the air and waiting for a mate. The males are only slightly smaller, but extremely active. Every night they will fly several kilometres in search of females, using their incredibly sensitive, feathery antenna to home in on the pheromone trail.

Atlas moths have a very short lifecycle for such large insects – they spend just six weeks as larvae, then six-eight weeks as a pupa. The caterpillars are rapacious eaters, going from an egg 2.5mm across to a caterpillar the size of a pork sausage. But when they emerge as an adult moth they have no mouthparts and live for just a week, using stored fat reserves to sustain themselves.

The statistics...

Atlas moth

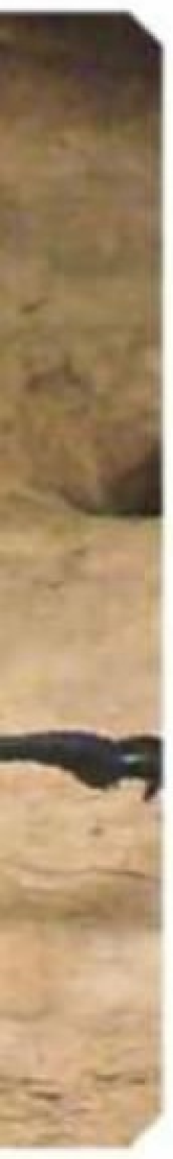
Size: 300mm (12in) wingspan

Weight: 25g

Diet: Citrus & evergreen leaves

Average life span in the wild: ~4 months

As big as: A handkerchief



RECORD BREAKERS

Biggest butterfly
Queen Alexandra's birdwing
Size: Up to 305mm

Biggest dragonfly
Giant petaltail dragonfly
Size: 152mm

Biggest praying mantis
Chinese mantis
Size: 100 x 15mm

Biggest grasshopper
Giant grasshopper
Size: Up to 90mm

Biggest earwig
Saint Helena earwig
Size: Up to 84mm

Biggest moth
Atlas moth
Size: 300mm

Biggest bee/wasp
Asian giant hornet
Size: 50mm

Biggest ant
Siafu ant
Size: Up to 50mm

Biggest fly
Gauromydas heros
Size: 100 x 60mm

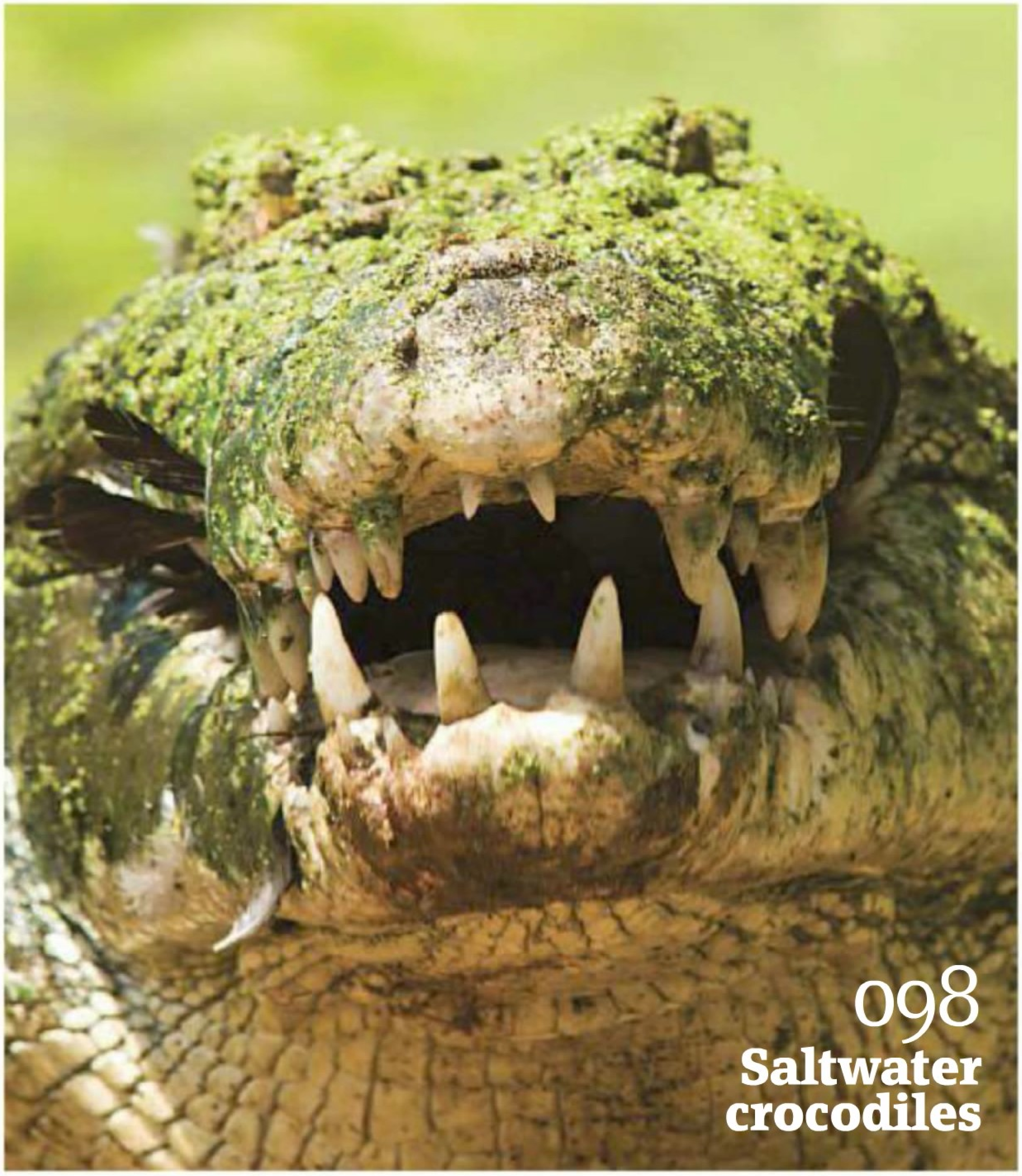
Biggest beetle
Goliath beetle
Size: 110 x 55mm

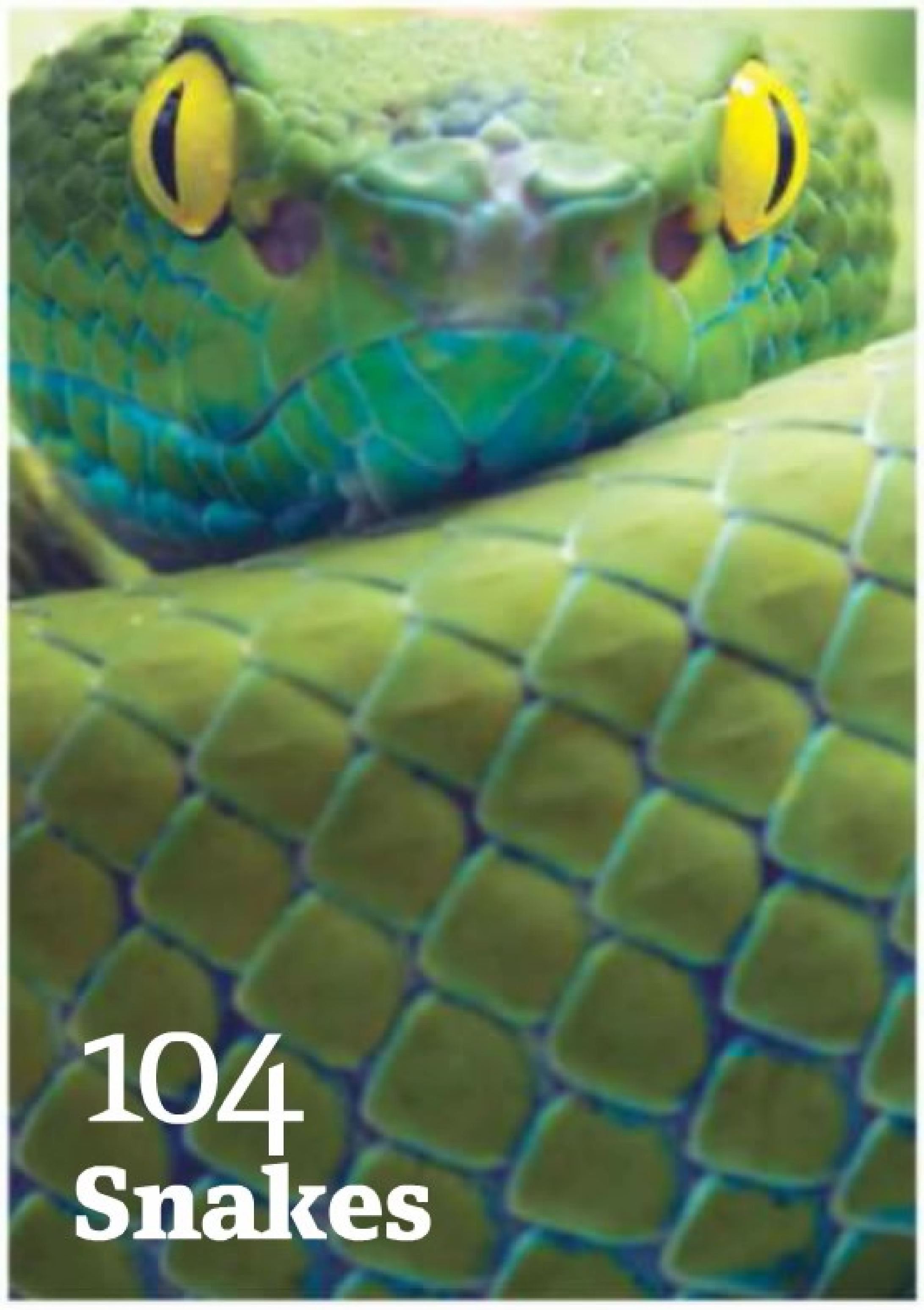
Biggest water insect
Giant water bug
Size: Up to 100mm

Biggest millipede
Giant pill millipede
Size: up to 80mm

Biggest stick insect
Lord Howe island phasmid
Size: Up to 120mm

REPTILES & AMPHIBIANS


098
Saltwater crocodiles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Snakes

Reptiles & amphibians

096 World's deadliest reptiles
Cold-blooded killers

100 Crocodiles
Largest lizards on the planet

102 Crocodile jaws
Strongest bite in the world

103 Death rolls
Tearing up dinner

104 Snakes
Stealthy sidewinders

106 Snake shedding
Slipping out of skin

106 Snake bites
The science of fangs

106 Jacobson's organ
Smelling sans noses

107 Rock pythons
Africa's largest snake

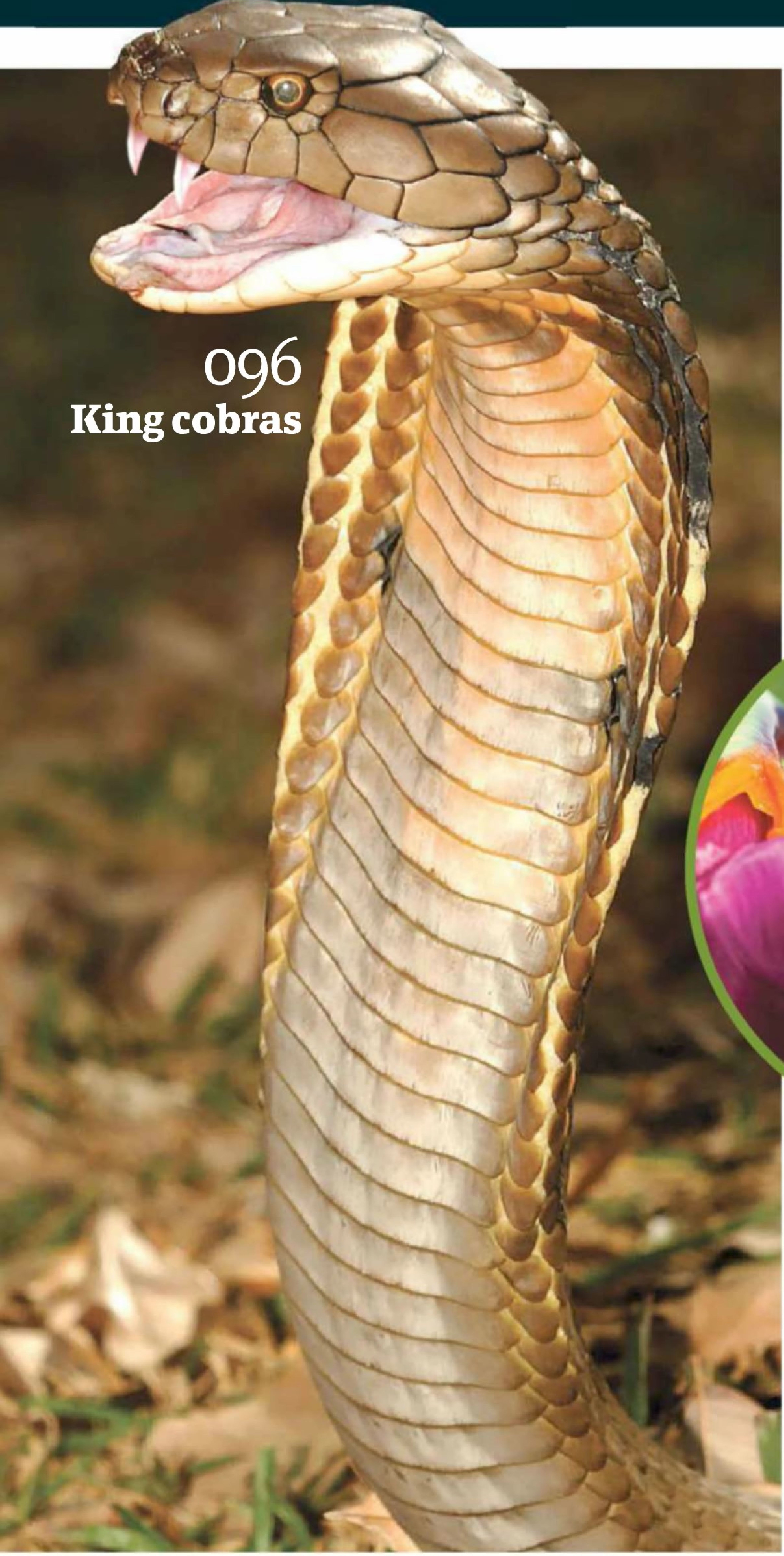
108 Amphibian skin
Breathing with skin

108 Amphibian life cycle
The tale of the tadpole

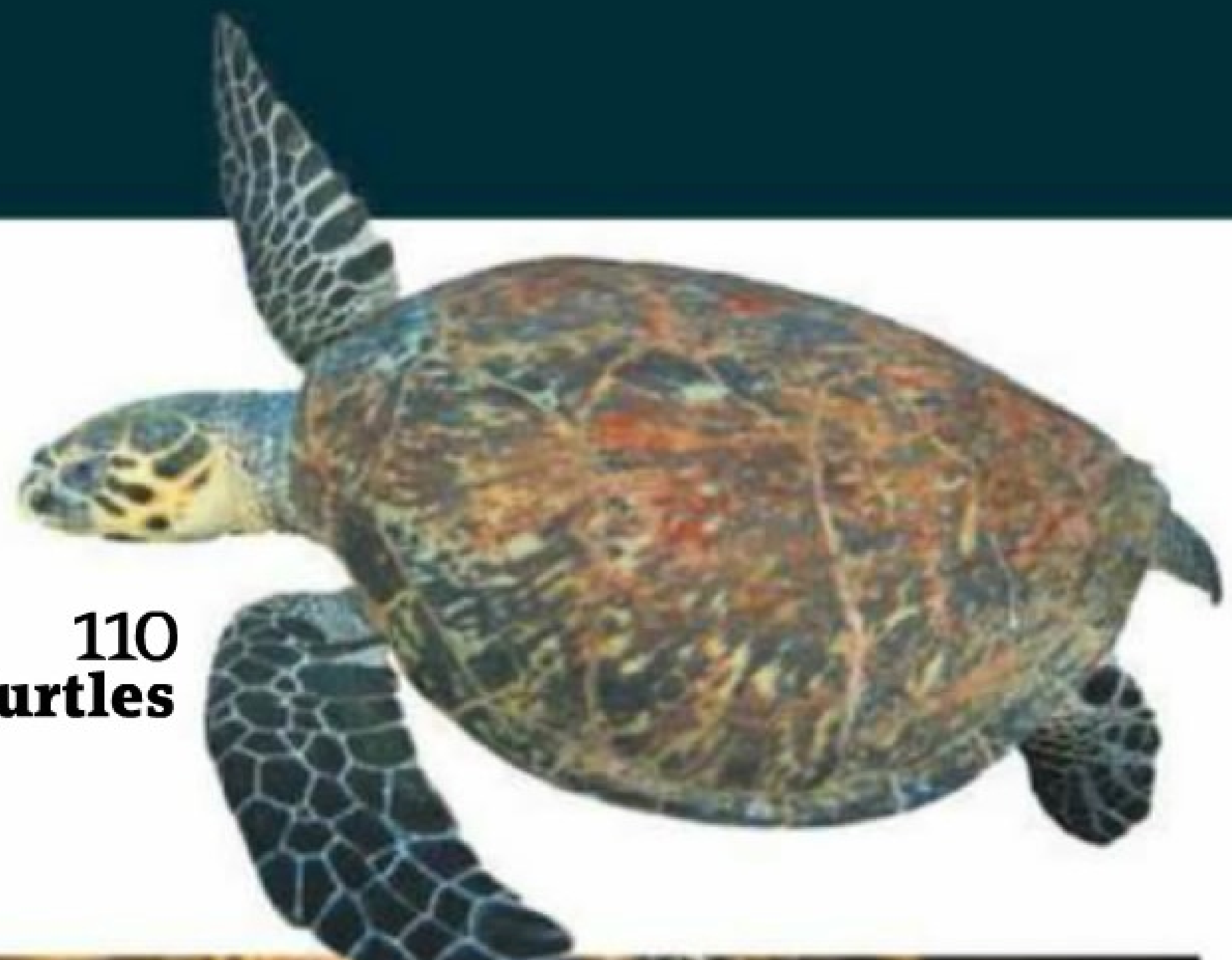
109 Frog leaps
Olympic-level jumpers

110 Turtles
Swimming with armour

097
Gila monsters



096 King cobras



110 Turtles

100 Crocodiles

108 Amphibian Life cycle

109 Frog leaps

World's deadliest reptiles

We take a look at the most dangerous reptiles on Earth

From snakes to crocodiles, the deadliest reptiles on our planet have a variety of ways to kill, stun or disable a foe. Some, like the king cobra, possess a fatal amount of venom that they inject into their prey, while others like the saltwater crocodile use their strength to overpower enemies.

Across all corners of the globe lurks a reptile with the potential to cause harm. While some are unjustly feared despite their timid nature, others are not nearly feared enough. Attacks on humans in most cases are rare due to the knowledge of how dangerous these creatures can be. However, they are not unheard of, and when one of these animals is cornered or threatened its aggressive nature can quickly become apparent.

Here we take a look at five of the most lethal carnivorous reptiles, pitting them head-to-head to find out which is the most deadly.

King cobra

The largest venomous snake in the world, it strikes fear into the heart of its prey

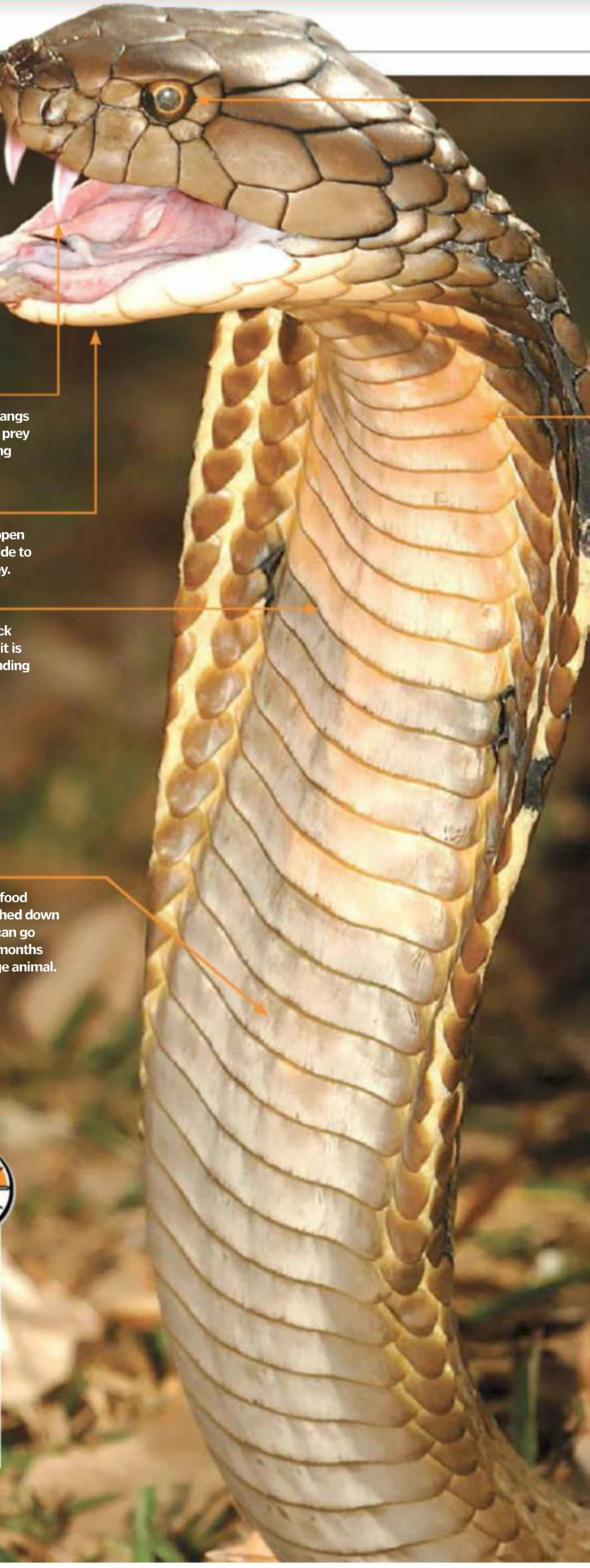
Fortunately for us, the king cobra is generally shy and will slink away from humans. However, when defending itself or its eggs it is one of the most deadly reptiles known to man. When facing an attacker the cobra is able to raise 1.8 metres off the ground and move forward to attack.

They live in undergrowth present in rainforests and humid jungles. One of their terrifying characteristics is the ability to slide up trees, surveying the area and finding prey from above. They primarily eat other snakes and smaller reptiles, preferably non-venomous snakes. To find prey, it can "smell" nearby chemicals with its forked tongue.

To kill, the king cobra strikes and pierces its prey with its fangs, injecting a lethal amount of venom. A single bite from a king cobra will typically contain 6-7ml of neurotoxin, which is enough to kill up to 20 people. It then devours the creature whole. They are the only snakes that make nests for their eggs, and a female king cobra will lay anywhere from 20-40 eggs at any one time. King cobras are generally found in South East Asia, with the largest living king cobras in Malaysia.

Not the friendliest pet in the world…

© Renaud d'Avout d'Auerstaedt



Fangs
Two short, fixed fangs inject venom into prey like a needle, killing them in minutes.

Jaws
King cobras can open their jaws very wide to swallow large prey.

Neck
The ribs on its neck can flatten when it is threatened, extending its hood.

Stomach
They digest their food slowly as it is pushed down their body. They can go without food for months after eating a large animal.

TIME TO DEATH
15 mins

5 TOP FACTS
REPTILES

Cold blooded

1 Reptiles are able to regulate their inner body temperature depending on the environment they are in, helping keep them alive in a number of different places and situations.

Skin

2 Reptiles have a dry and scaly skin that contains high levels of keratin, which prevents water loss and helps regulate the internal body temperature.

Heart

3 All reptiles have a three-chambered heart to pump blood around the entire body except crocodiles, which have four chambers just like humans.

Eggs

4 Most reptiles lay eggs with a hard shell, and baby reptiles develop within the eggs from which they hatch, requiring both food and air immediately.

Air

5 Although some reptiles reside in or near water, they need a constant supply of air unlike amphibians, who live underwater when they are born.

DID YOU KNOW? *There is enough venom in one bite from a king cobra to kill an elephant*

King of the cobras

What makes this snake so deadly?

Eyes and ears
King cobras can see 100m away, and although they have no ears they can "hear" sound vibrations.

Skin
They shed their smooth-scaled skin about five times a year.

The statistics...

King cobra

Genus: Ophiophagus
Length: 3.6-5.5m
Weight: 6-9kg
Top speed: 10mph
Life span: 20 years

Kill factor

King cobra

Aggression: Generally shy, but make it mad and you'll quickly discover its bad temper.

Intelligence: Uses its hood, hiss and speed to its advantage when confronted.

Speed: Agile and quick, they can pounce forwards up to an incredible two metres.

Strength: On rare occasions they will use their muscular body to constrict prey.

Other: The fatality rate from its venom is up to 75 per cent, and can be as quick as 15 minutes.

Deadly rating:
☠ ☠ ☠ ☠ ☠

Gila monster

The only venomous lizard which lives in the United States is shy but can be very deadly

Found across several states in America including Nevada and California, the Gila monster is known for being timid but potentially very deadly. Its main source of attack is its venom. The teeth of a Gila monster have grooves which channel the venom into the wounds of its prey. They are average-sized lizards with powerful jaws and short legs adapted for digging.

Identifiable by their characteristic black bodies interspersed with orange, pink and yellow, Gilas are lethargic creatures that spend about 95 per cent of their lives underground in burrows. They eat mainly bird or reptile eggs and on occasion small birds, lizards and mammals. They are commonly thought to be very deadly and dangerous reptiles. However, their venom is primarily used for self-defence. They tend to bite their prey by surprise and come back when the venom has taken effect. Unless threatened, Gila monsters will only attack when seeking a meal.

Caution! Handle with care!

Good looks
A stout body and beadlike scales, the Gila monster tends to reside in harsh desert environments.

Is it a monster?

The human risk is low, but this beast can be deadly

A hungry Gila can deliver a nasty nip

Fatty deposits
Gila monsters store fat in their tails – like a camel does in its hump – to be used during hibernation.

Kill factor

Gila monster

Aggression: Generally run or hide rather than fight.

Intelligence: Coloured scales allow limited camouflage when avoiding predators.

Speed: Sluggish and slow. Avoiding one shouldn't be too hard for a human.

Strength: Quite weak. They use venom to assist in hunting prey.

Other: Although deadly to smaller animals, its venom is rarely fatal in humans.

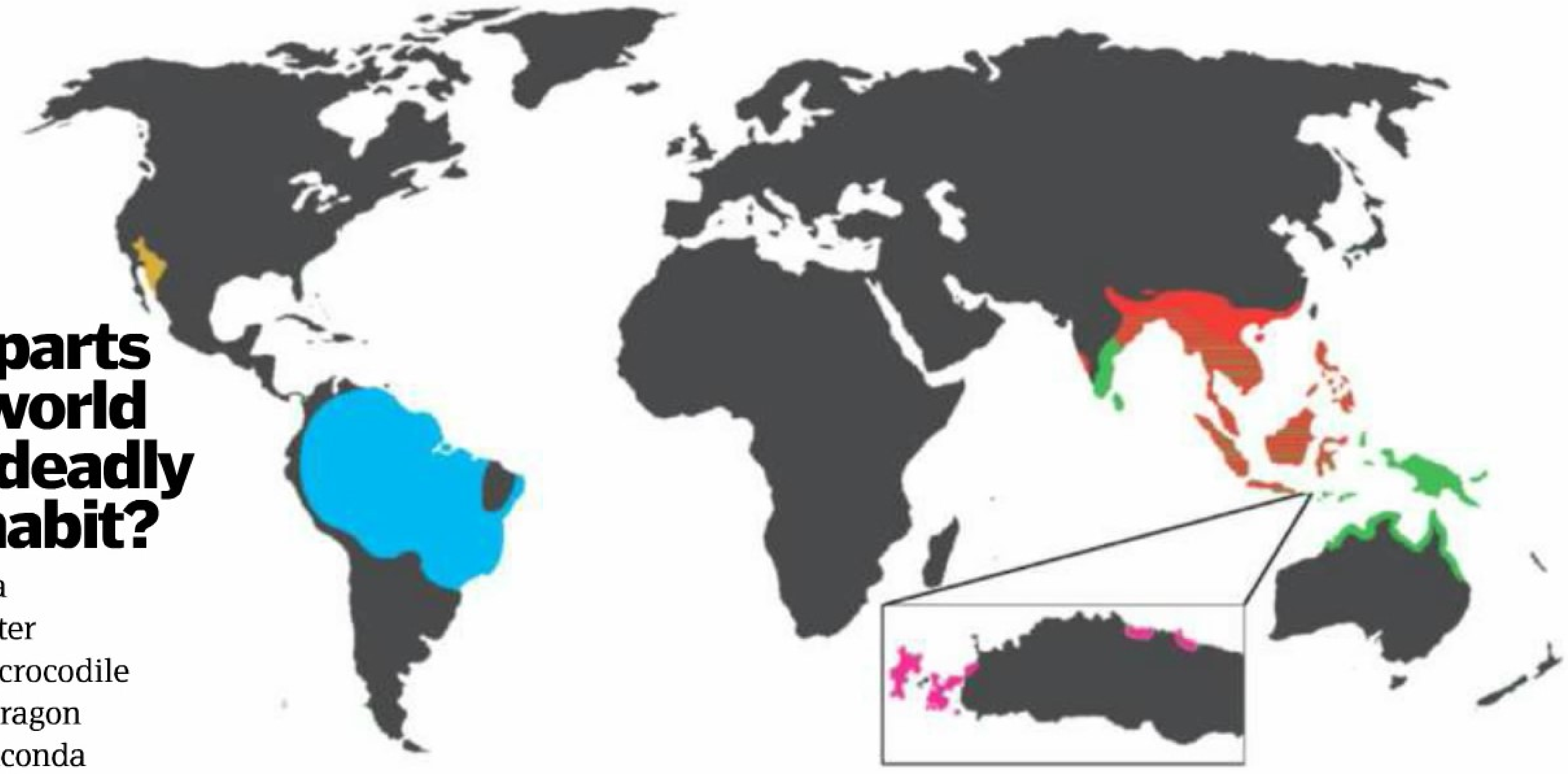
Deadly rating:
☠ ☠

The statistics...

Gila monster

Genus: Heloderma
Length: 30-60cm
Weight: 1.3-2.2kg
Top speed: 15mph
Life span: 30 years

Which parts of the world do our deadly five inhabit?



🟥 King cobra
🟧 Gila monster
🟩 Saltwater crocodile
🟪 Komodo dragon
🟦 Green anaconda

Xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Kill factor

Saltwater crocodile

Aggression: Very dangerous, particularly in mating season.

Intelligence: Use very clever hunting tactics.

Speed: Fast swimmers and slow walkers but have a quick leap.

Strength: A powerful bite and a muscular tail. Very strong.

Other: Young crocs are forced out of their home territory by domineering adults.

Deadly rating: ☠☠☠☠☠

TIME TO DEATH
60 secs

The statistics...

Saltwater crocodile

Genus: Crocodylus
Length: 2.1-7.0m
Weight: 408-1,000kg
Top speed: 25mph
Life span: 70 years

Who knew they could do camouflage too?

Tail
The strong tail of a Komodo dragon is often longer than its body.

© Midori

Kill factor

Komodo dragon

Aggression: Multiple attacks on Indonesian villages back in 2009 showed the dragon's aggressive potential.

Intelligence: Komodo dragons are smart animals, particularly when hunting.

Speed: Appear clumsy but can move as fast as a dog, and are excellent swimmers.

Strength: Weak bite but strong claws, and their tail can knock down large mammals like pigs.

Other: Slow acting but deadly venom. Dragons are typically quite solitary.

Deadly rating: ☠☠☠☠

The statistics...

Komodo dragon

Genus: Varanus
Length: 2-3m
Weight: 68-91kg
Top speed: 15mph
Life span: 30 years

Saltwater crocodile

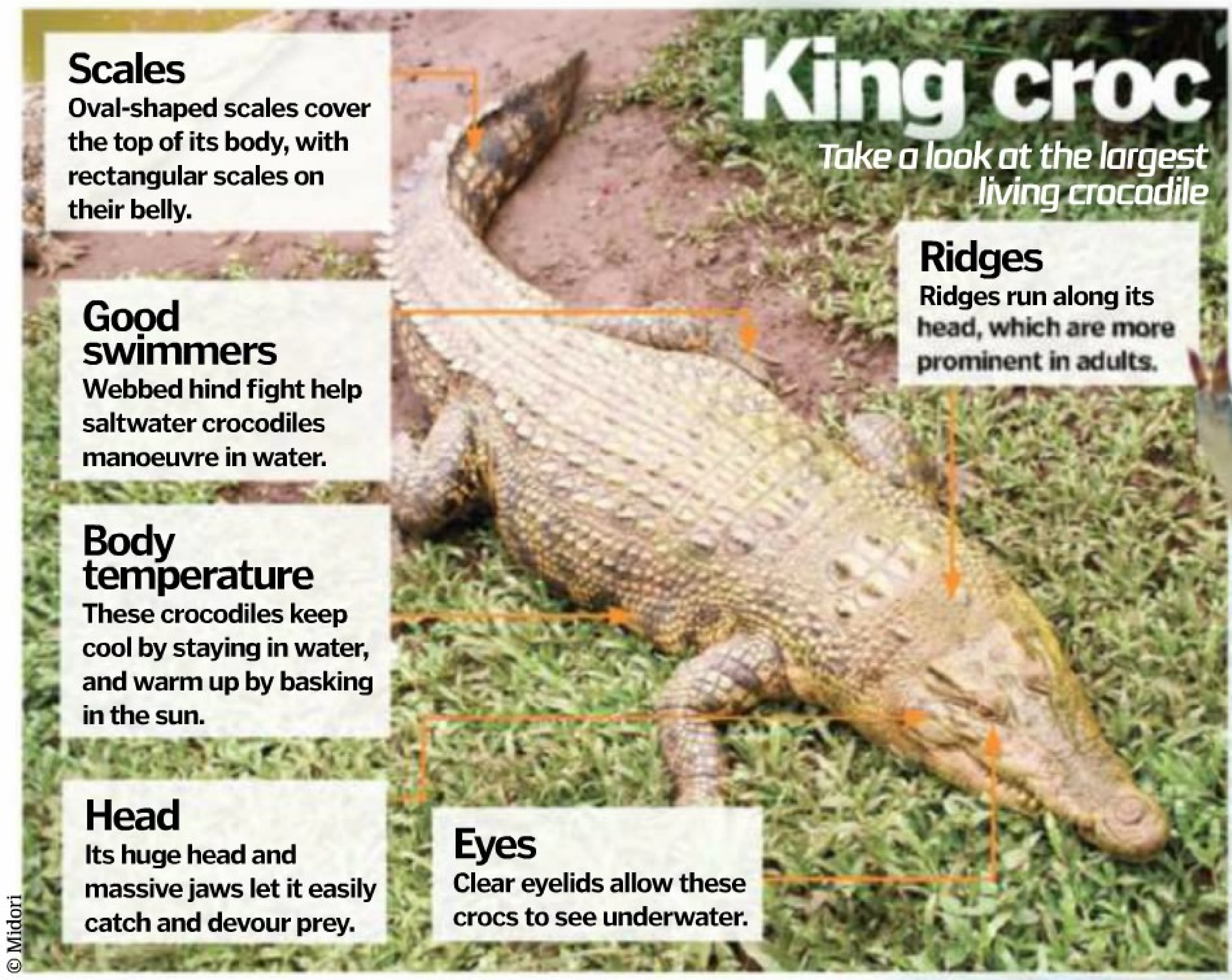
The largest living crocodilian on Earth eats anything, even humans

When tackling large prey or attackers, the saltwater crocodile will typically overpower, drown and then dismember them. The crocodile can hold its prey underwater as it can separate its mouth from its throat, allowing it to open its massive jaw when fully submerged. To finish off its prey it will either drag it to land or hold it above water and swallow it vertically.

They are very intelligent creatures, lurking beneath the surface of the water until potential prey arrives for a drink. Using their powerful tail, they then suddenly leap out of the water and drag their prey back underwater. In the last 25 years they have been responsible for the death of about a dozen people.

They mostly eat small fish and land vertebrates but they are not picky eaters. Any mammal in its vicinity is good food as far as a saltwater crocodile is concerned. They have even been known to attack boats, mistaking them for enemies. Their jaws have a biting force of up to 2,300kg per square inch, the most powerful bite on the planet. On land they use their strong legs to move, while underwater they use their giant tail for propulsion.

They are generally found in brackish (slightly salty) waters such as rivers, swamps and estuaries. They are also occasionally seen in the open sea as they can swim up to 620 miles (1,000km), but they are most commonly found in northern Australia, southeast Asia and eastern India.



King croc

Take a look at the largest living crocodile

Scales
Oval-shaped scales cover the top of its body, with rectangular scales on their belly.

Good swimmers
Webbed hind fight help saltwater crocodiles manoeuvre in water.

Body temperature
These crocodiles keep cool by staying in water, and warm up by basking in the sun.

Head
Its huge head and massive jaws let it easily catch and devour prey.

Eyes
Clear eyelids allow these crocs to see underwater.

Ridges
Ridges run along its head, which are more prominent in adults.

© Midori

A beast that can kill in just seconds

Head to Head KILL METHODS

© Mats Stafseng Einarsen

1. Bite

Some reptiles seep venom into their prey when they bite, coming back to finish off their enemy up to a week later when the venom has taken effect.

2. Venom

Toxins target the nerves and muscles in prey which provide movement, often rendering animals completely immobile in under an hour.

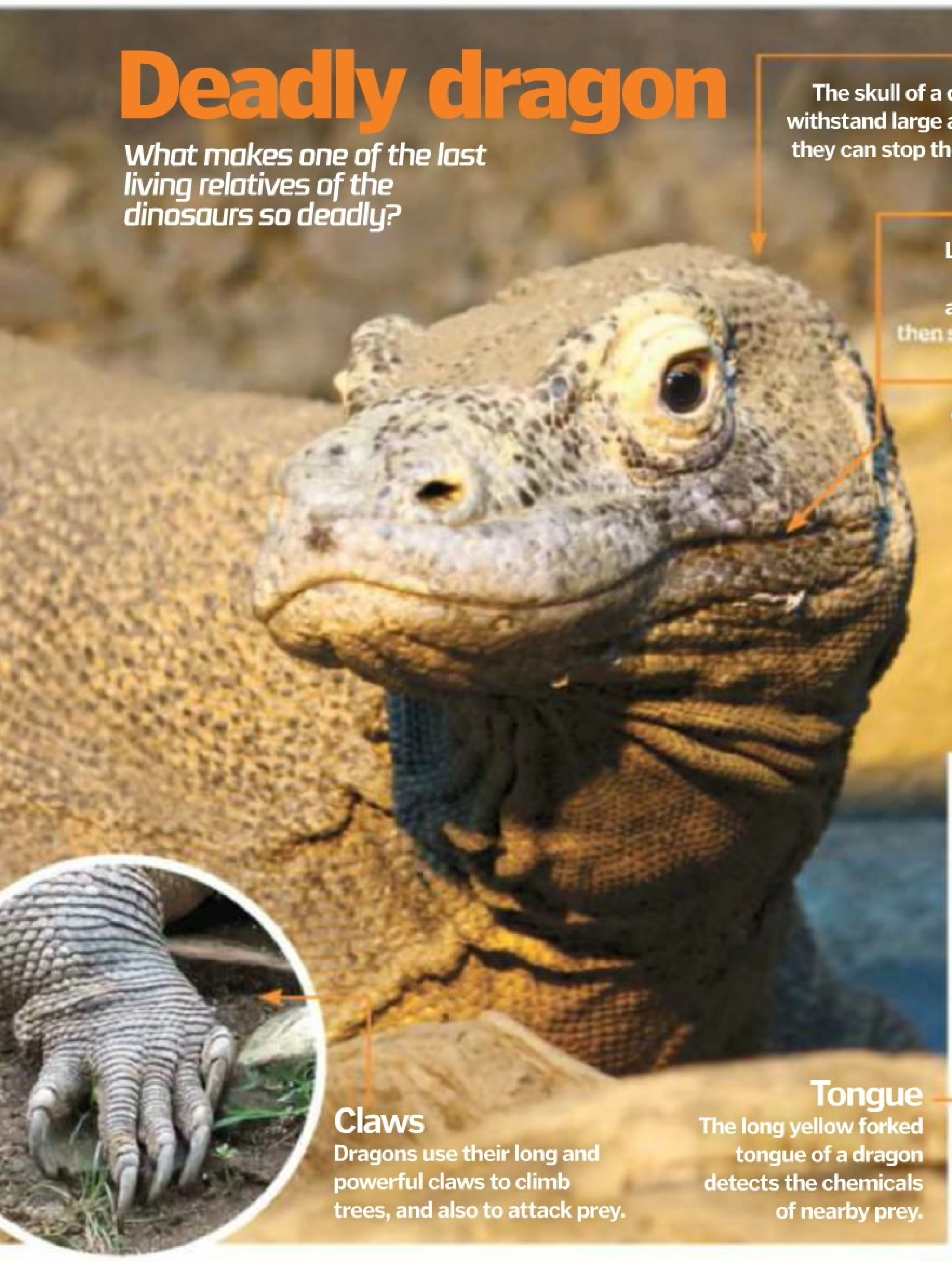
3. Constriction

Reptiles such as the anaconda asphyxiate their prey by coiling their body around that of the prey, stopping them breathing and killing them in minutes.

DID YOU KNOW? *The Komodo dragon was discovered in WW1, when a pilot saw the reptiles after swimming to Komodo Island*

Deadly dragon

What makes one of the last living relatives of the dinosaurs so deadly?



Skull
The skull of a dragon is designed to withstand large amounts of stress, so they can stop their prey pulling away.

Poison
Large glands channel venom between the animal's teeth, which then seeps into their prey.

Teeth
60 razor-sharp teeth help them literally tear their prey into shreds, known as pull-feeding.

Claws
Dragons use their long and powerful claws to climb trees, and also to attack prey.

Tongue
The long yellow forked tongue of a dragon detects the chemicals of nearby prey.

The world's deadliest hand puppet...

Komodo dragon

The world's heaviest living lizard is also one of the most dangerous reptiles

These huge lizards like to live an isolated existence except during mating season, when males will patrol and defend a territory up to 1.2 miles long per day. They are found only on a small group of Indonesian islands in the Flores and Bali seas.

Komodo dragons are cannibalistic, but will also eat large prey such as pigs and deer of a similar size to themselves. Like saltwater crocodiles they are not fussy eaters, and will eat almost anything they can overpower including other dragons. They are very quick eaters; a 45kg dragon was observed to eat a pig almost its own weight in 20 minutes, equivalent to a human eating 320 quarter-pound hamburgers in the same time.

It was only discovered in 2009 that Komodo dragons possess a deadly amount of venom, which they use to kill their prey. When hunting, a dragon will keep a vice-like grip on its prey with its mouth. Venom then seeps into large wounds on the prey made by the teeth. The prey goes into shock and bleeds to death. Although they have a similar-sized skull to that of a saltwater crocodile, the bite of a dragon is only one-sixth as strong.

Kill factor

Green anaconda

Aggression: Short-tempered reptiles, and even more so when in captivity. Not good pets.

Intelligence: These ambush predators wait for the perfect opportunity to attack prey.

Speed: Slow on land but quick and deadly in the water.

Strength: Capable of killing large animals such as jaguars with their strong body.

Other: One of the few reptiles that gives birth to live young.

Deadly rating:

☠☠☠½

Green anaconda

The biggest snake in the world is at its most dangerous when underwater

Although its cousin, the reticulated python, might be longer than the green anaconda, it pales in girth comparison, as the anaconda is not only long but also incredibly thick. They are one of the few reptiles where the females outsize the males. They tend to live in swampy marshes and streams in the tropical rainforests of the Amazon and Orinoco basins. On land they are slow and clunky but in water they are reptiles to be reckoned with. Like the saltwater crocodile, they wait submerged in water for prey to approach, using their eyes and nostrils on the top of their head to see around and breathe.

Like the king cobra the green anaconda swallows its prey whole, digesting it as it moves down its body. Its teeth are angled backwards, so that once it has bitten its prey, any attempts to escape will only impale the animal further. They feed on animals as large as jaguars and also pigs and deer. Their main method of attack is constriction; they are known as nonvenomous constrictors. They wrap their bodies around prey and squeeze until asphyxiation occurs. Again, they can go months without eating after a large meal.

The statistics...

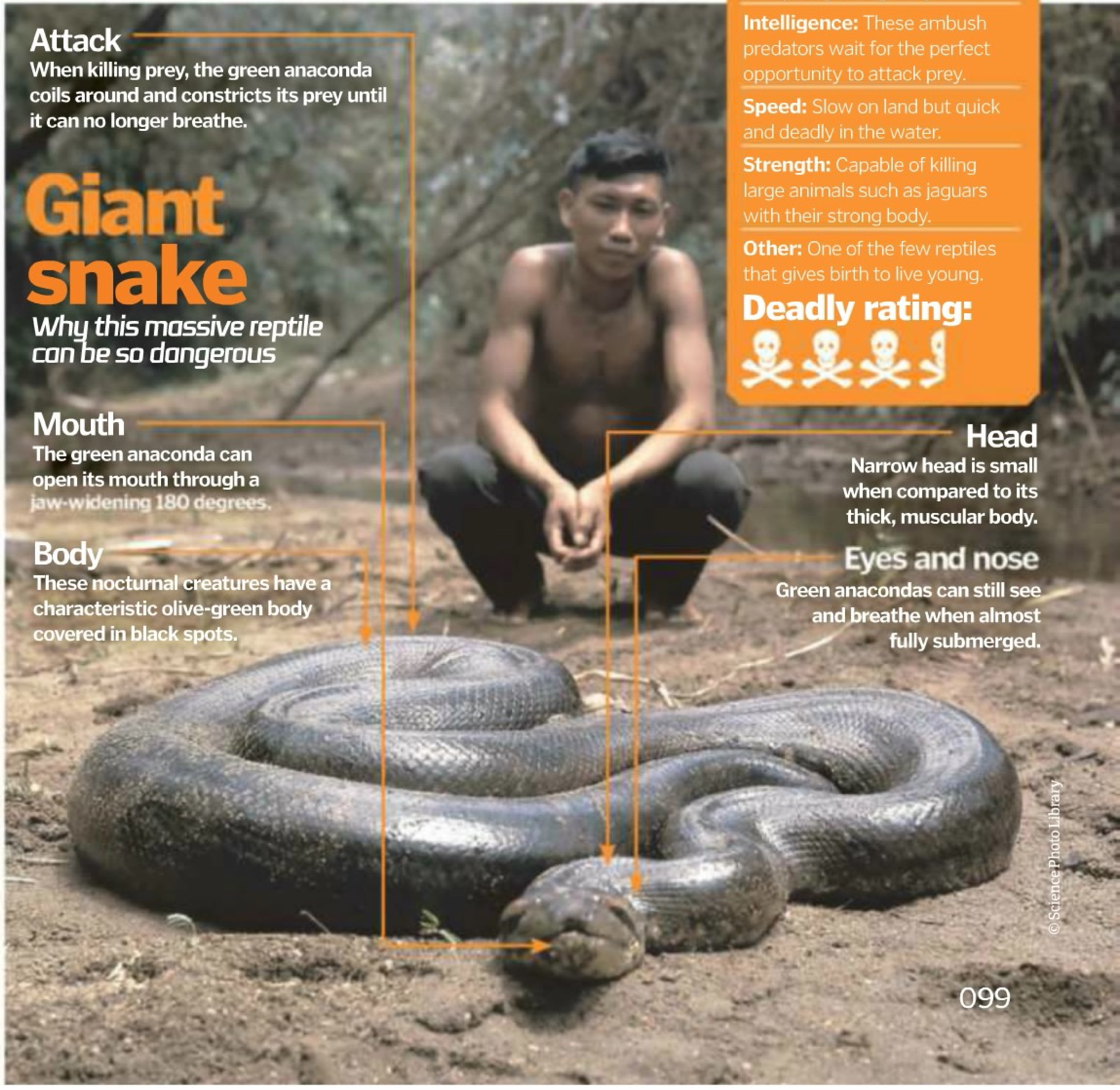
Green anaconda

Genus: Eunectes
Length: 6-9m
Weight: 132-227kg
Top speed: 13mph
Life span: 10 years

TIME TO DEATH
2 mins

Giant snake

Why this massive reptile can be so dangerous



Attack
When killing prey, the green anaconda coils around and constricts its prey until it can no longer breathe.

Mouth
The green anaconda can open its mouth through a jaw-widening 180 degrees.

Body
These nocturnal creatures have a characteristic olive-green body covered in black spots.

Head
Narrow head is small when compared to its thick, muscular body.

Eyes and nose
Green anacondas can still see and breathe when almost fully submerged.

©Science Photo Library

How crocodiles hunt prey

They outlived the dinosaurs but these hunters are anything but elderly

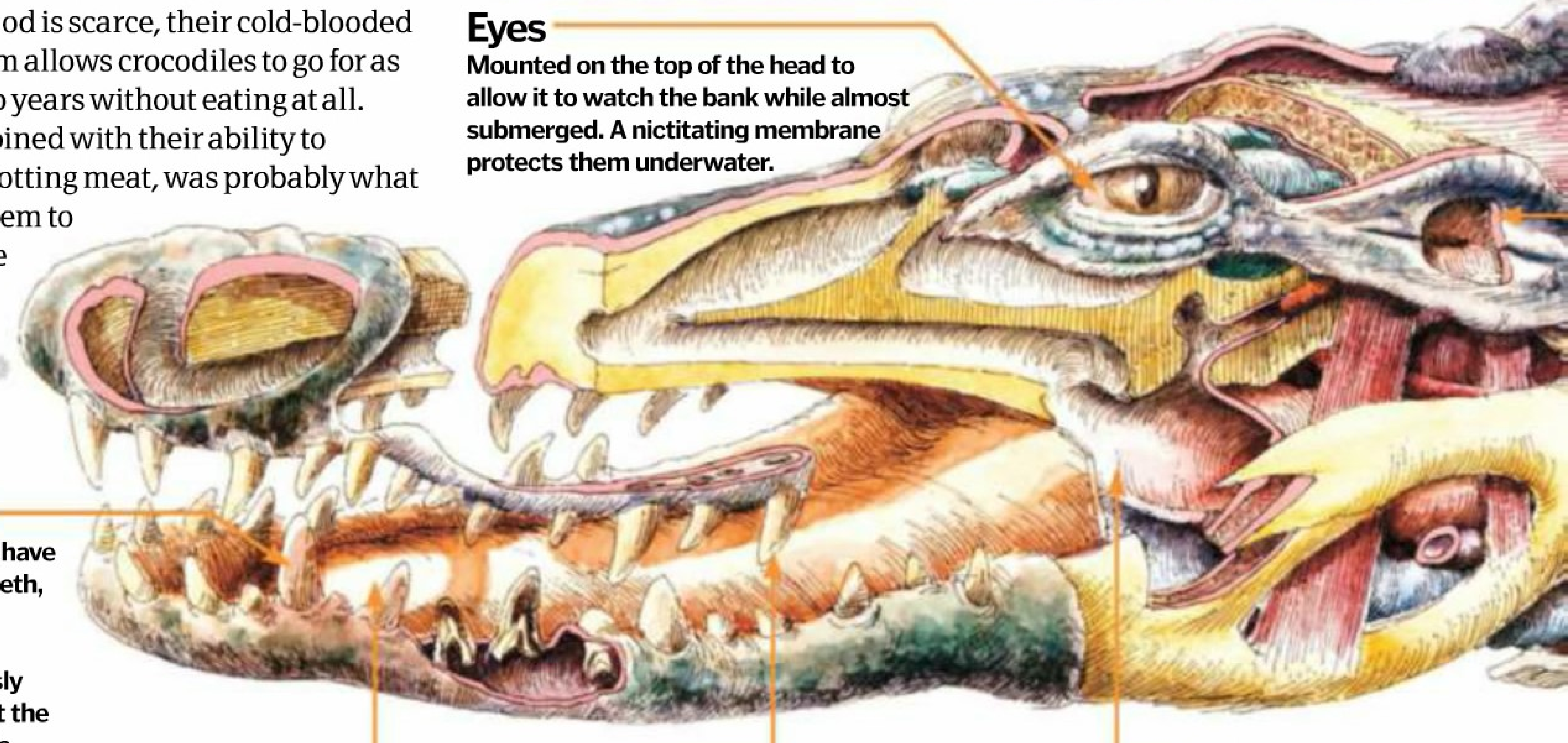
A stealthy croc spies its prey from the water

Crocodiles are often described as living fossils, but despite the fact that their body shape hasn't changed much in the last 200 million years, they are actually some of the most sophisticated reptiles on Earth.

Like all living reptiles, they are cold blooded but that doesn't make them sluggish. Crocodiles have a four-chambered heart and muscles that mimic our diaphragm to ensure they can quickly pump oxygen around their bodies for explosive bursts of speed. Crocodiles are ambush predators; their preferred tactic is to lurk in the river with just their eyes and nostrils visible above the surface and burst out of the water to surprise animals that have come to the bank to drink. If their initial lunge fails, they can chase prey over land at speeds of 17kph. The galloping gait of the crocodile was dismissed as a folk legend for many years, simply because hardly anyone who witnessed it lived to tell the tale.

Once a crocodile has grabbed its prey, it will drag it into the water and pull it under. Crocodiles need air to breathe but they can hold their breath for 30 minutes and drowning your prey is easier and more reliable than risking it escaping if you unclamp your jaws. Crocodile teeth are only designed for gripping and puncturing; they have no incisors or carnassials to slice meat off a carcass. Instead they will grip a chunk of flesh with the front teeth and spin violently on their long axis to twist off a bite-sized piece. Crocodiles don't have lips so they can't seal their mouth shut when eating. This means they can't swallow food underwater without drowning themselves so each torn off mouthful has to be brought to the surface and tossed into the back of the mouth.

When food is scarce, their cold-blooded metabolism allows crocodiles to go for as long as two years without eating at all. This, combined with their ability to scavenge rotting meat, was probably what allowed them to survive the event that killed the dinosaurs.



Eyes
Mounted on the top of the head to allow it to watch the bank while almost submerged. A nictitating membrane protects them underwater.

Teeth
Crocodiles have 64 to 70 teeth, which are replaced continuously throughout the animal's life.

Tongue
A crocodile can't stick its tongue out of its mouth because it is anchored to the floor of the mouth all the way along.

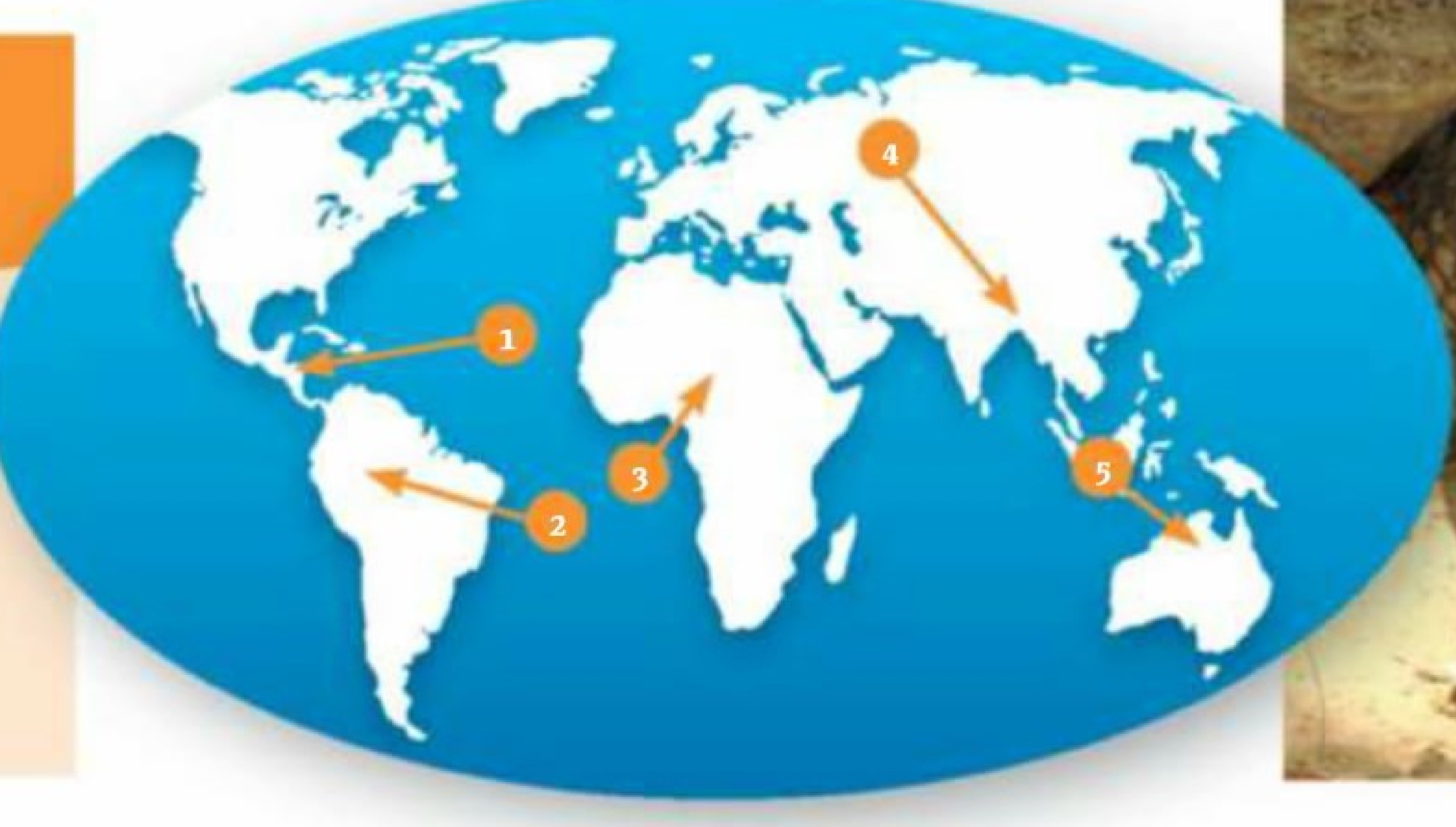
Salt glands
Special glands on the top of the tongue allow crocodiles to excrete salt that builds up in their blood in saltwater environments.

Jaw muscle
The massive muscle and its placement a long way forward of the hinge provides a bite pressure almost twice that of a great white shark.

Although the teeth are deadly its the death grip that kills

© Adam Jones adamjones.freeservers.com

ON THE MAP



Where to find crocodiles

1 Central America
2 The Amazon Rainforest
3 Sub-Saharan Africa
4 Tropical regions of Asia and the Far East
5 Northern Australia

DID YOU KNOW?

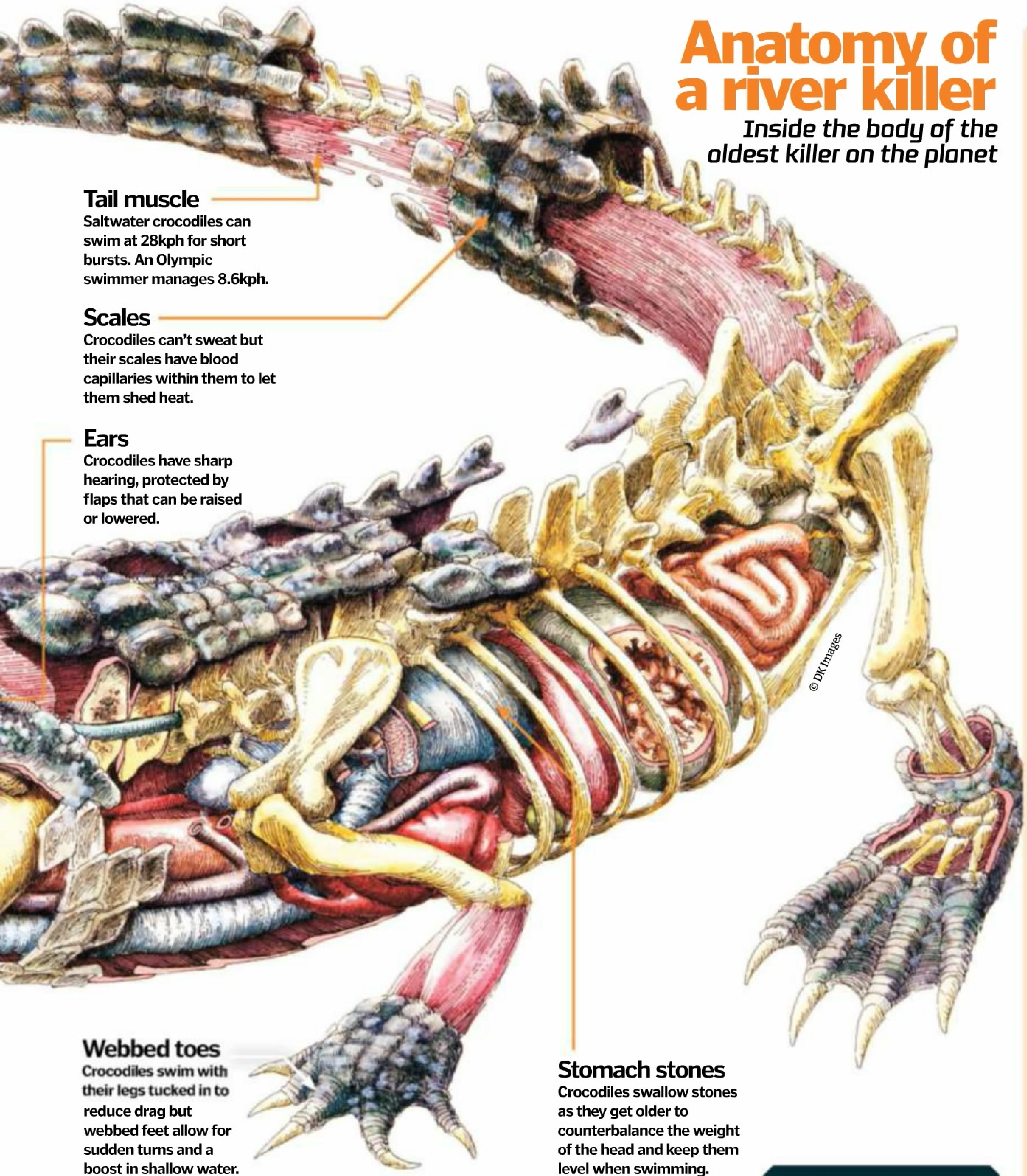
Let's talk about sex

Crocodiles don't have sex chromosomes. Instead the sex of a crocodile is determined by the temperature its egg is incubated at. If it is close to 31.6°C it will hatch as a male; anything higher or lower than that produces a female.

DID YOU KNOW? *The largest crocodile in the world is called Utan and measures over six metres long*

Anatomy of a river killer

Inside the body of the oldest killer on the planet



© DK Images

Tail muscle
Saltwater crocodiles can swim at 28kph for short bursts. An Olympic swimmer manages 8.6kph.

Scales
Crocodiles can't sweat but their scales have blood capillaries within them to let them shed heat.

Ears
Crocodiles have sharp hearing, protected by flaps that can be raised or lowered.

Webbed toes
Crocodiles swim with their legs tucked in to reduce drag but webbed feet allow for sudden turns and a boost in shallow water.

Stomach stones
Crocodiles swallow stones as they get older to counterbalance the weight of the head and keep them level when swimming.

Please don't try this one at home

© Cameloctober

The statistics…

Crocodiles

Type: Reptile

Diet: Carnivore

Average life span in the wild: 70 years

Weight: 1,200kg

Size: 4.85m

Crocodile or alligator?

A field spotter's guide to carnivorous reptiles

Crocodile

Location: Crocodiles live in Africa, Asia, Australia and the Americas, in both fresh and saltwater.

Snout shape: The V-shaped snout is a general-purpose design for catching fish, reptiles and mammals.

Jaws/teeth: The upper and lower jaws are the same width, so the fourth tooth in the lower jaw sticks up.

Colour: Mottled green or sandy yellow, with slightly darker scales along the back and tail.

Skin: Each scale has a pore near the edge, visible even on crocodile handbags and wallets.

© Luisfi

Alligator

Location: Alligators are only found in the southern United States and China and vastly prefer freshwater.

Snout shape: A heavier, U-shaped snout provides extra strength for cracking turtle shells.

Jaws/teeth: A wider upper jaw completely covers all the teeth in the lower jaw when the mouth is closed.

Colour: Much darker, sometimes almost completely black, depending on the water quality.

Skin: Alligators only have pores on the scales that are covering the upper and lower jaws.

Other
A crocodile with a very long, thin snout, is actually a gharial. Caimans look like a slightly smaller alligator, but you can tell them apart because the large scales on their head form a four-four-two pattern, instead of two-two-two.

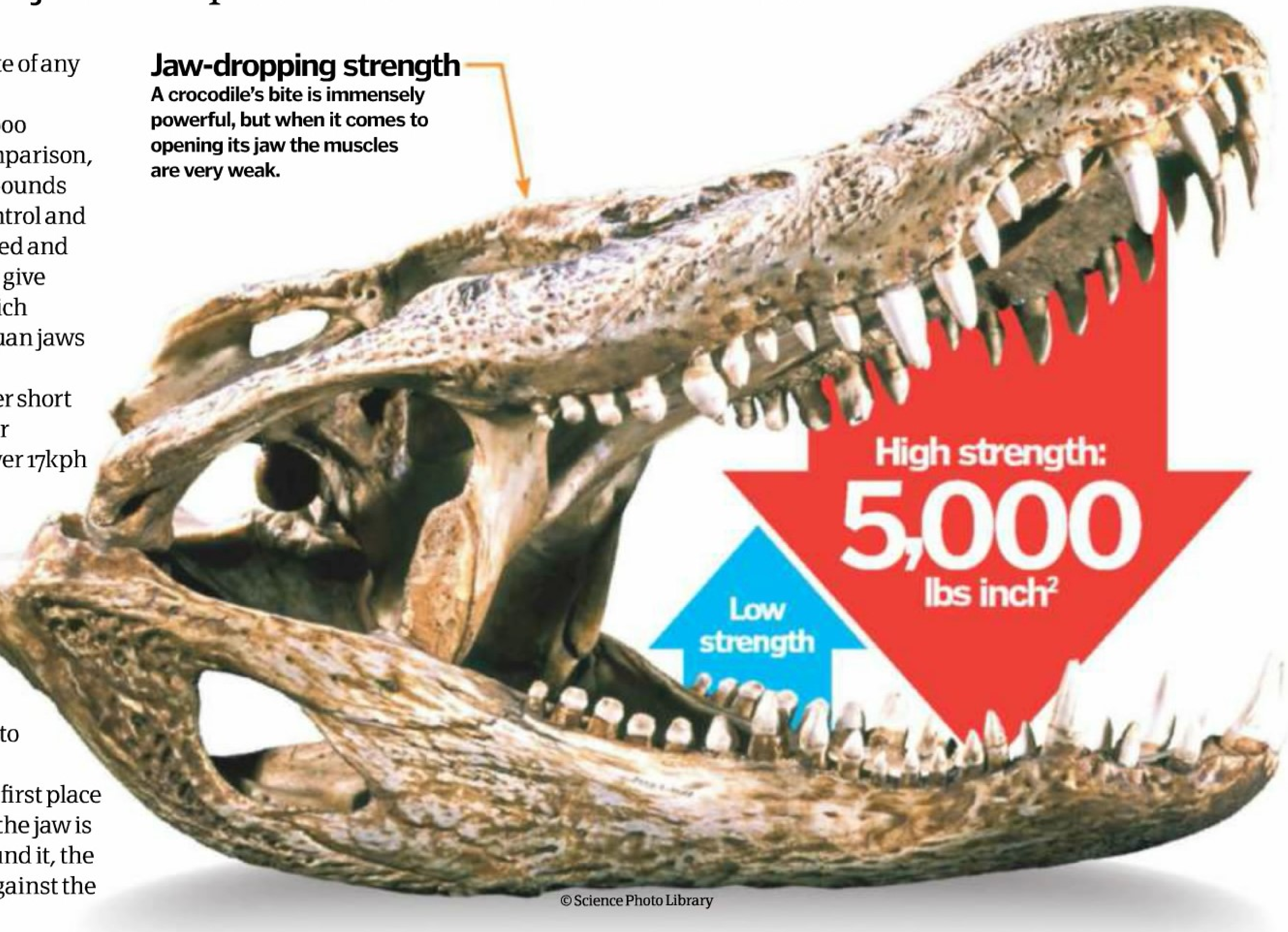
The strongest jaws on the planet

Why do crocodiles have the strongest bite of any creature known, yet are not able to open their jaw if we place an elastic band around it?

A crocodile has the strongest bite of any known creature, producing a phenomenal force of around 5,000 pounds per square inch. By comparison, the great white shark only has a bite of 400 pounds per square inch. The sets of muscles that control and give power to the crocodile's bite have evolved and developed to be extraordinarily strong, and give crocodiles a natural weapon the likes of which mostly went extinct along with the gargantuan jaws of the dinosaurs.

Alongside their relatively quick speed over short distances on land – an Australian freshwater crocodile was recorded as running at just over 17kph (11mph) for around 20-30 metres – and the immensely sharp teeth that crocodiles prominently display, this incredible bite forms an immense weapon for the crocodiles to successfully hunt and kill with inside a competitive aquatic environment.

However, although the jaw muscles used to snap the jaw shut are well developed, the muscles that are used to open the jaw in the first place are considerably weaker. So much so that if the jaw is taped shut or a large rubber band is put around it, the muscles are not strong enough to push up against the force created by these.

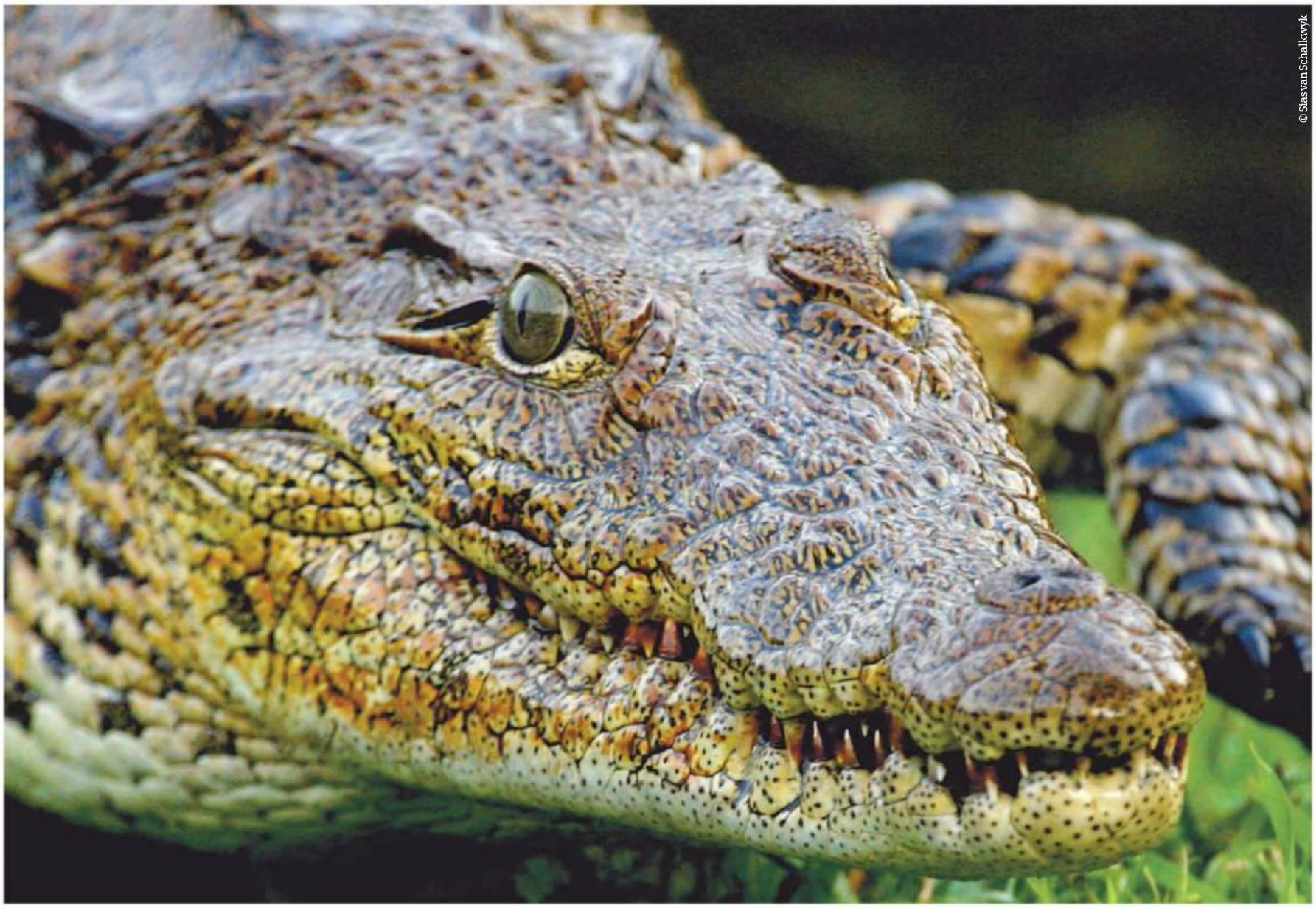


Jaw-dropping strength

A crocodile's bite is immensely powerful, but when it comes to opening its jaw the muscles are very weak.

© Science Photo Library

He hasn't lost a game of snap yet!


© Sias van Schalkwyk

Death rolls

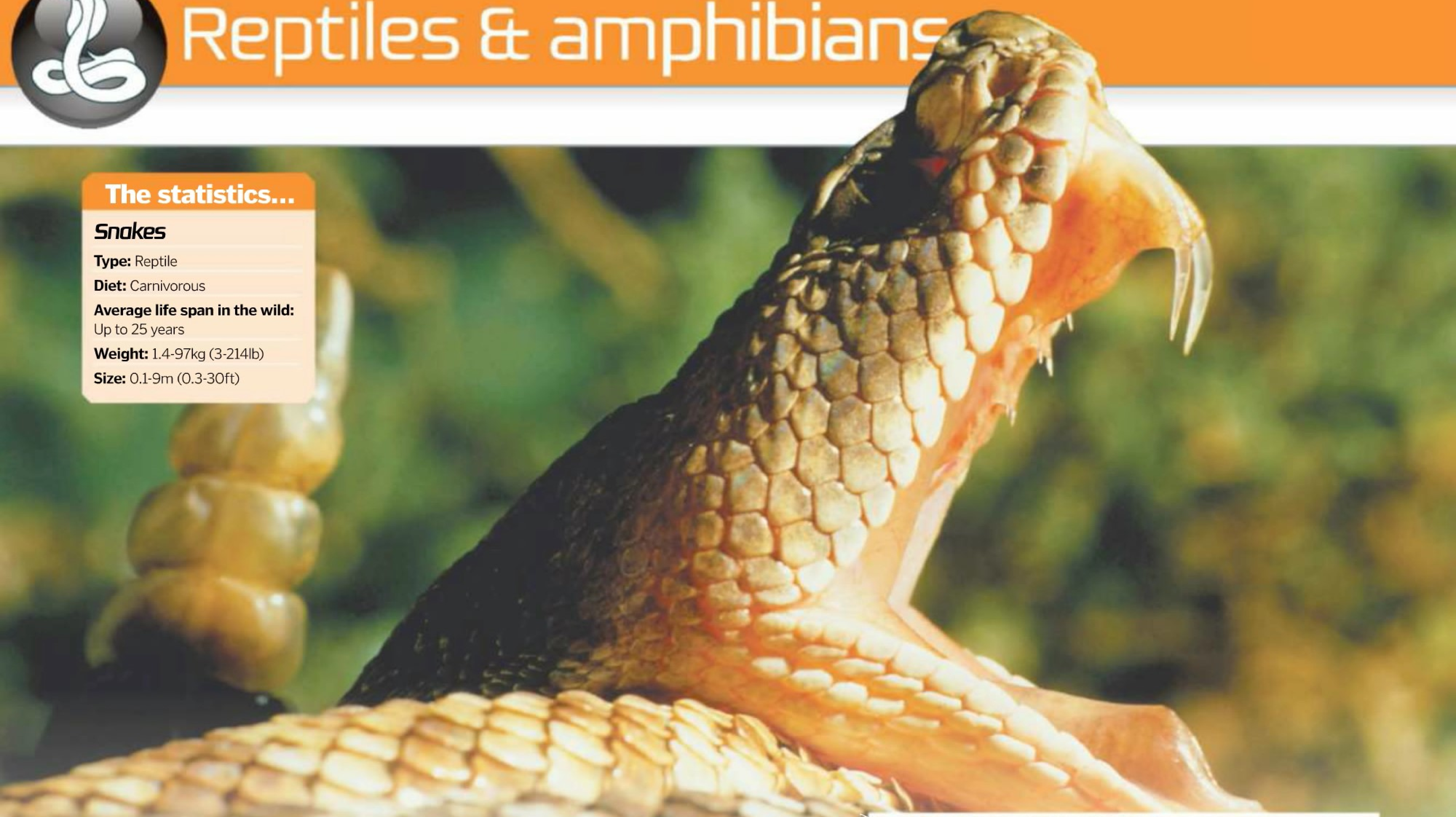
How crocs employ this tactic

Commonly misunderstood, the crocodile death roll is a unique method to feed off previously killed prey, not a method to kill them. The most famous user of the death roll is the Nile species of crocodile, common to the Nile River in Egypt. Here, crocodiles use their camouflage and speed to grab large prey and drag them into the water. Once there, the crocodile proceeds to drag the target underwater, holding it there until it drowns. Once the prey is dead, the crocodile then performs the death roll in order to tear large chunks of flesh off its body quickly and efficiently. To do this, it buries its large teeth into the creature's flesh, before rolling its body 360 degrees. The muscular force of the crocodile's body in partnership with the sharpness of its teeth proceed to tear the prey open, something that would prove difficult within the water while stationary.

> "The death roll is a unique method to feed off killed prey, not a method to kill them"

Marsh crocs basking in the sun

© Kmanoj



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The statistics…

Snakes

Type: Reptile

Diet: Carnivorous

Average life span in the wild: Up to 25 years

Weight: 1.4-97kg (3-214lb)

Size: 0.1-9m (0.3-30ft)

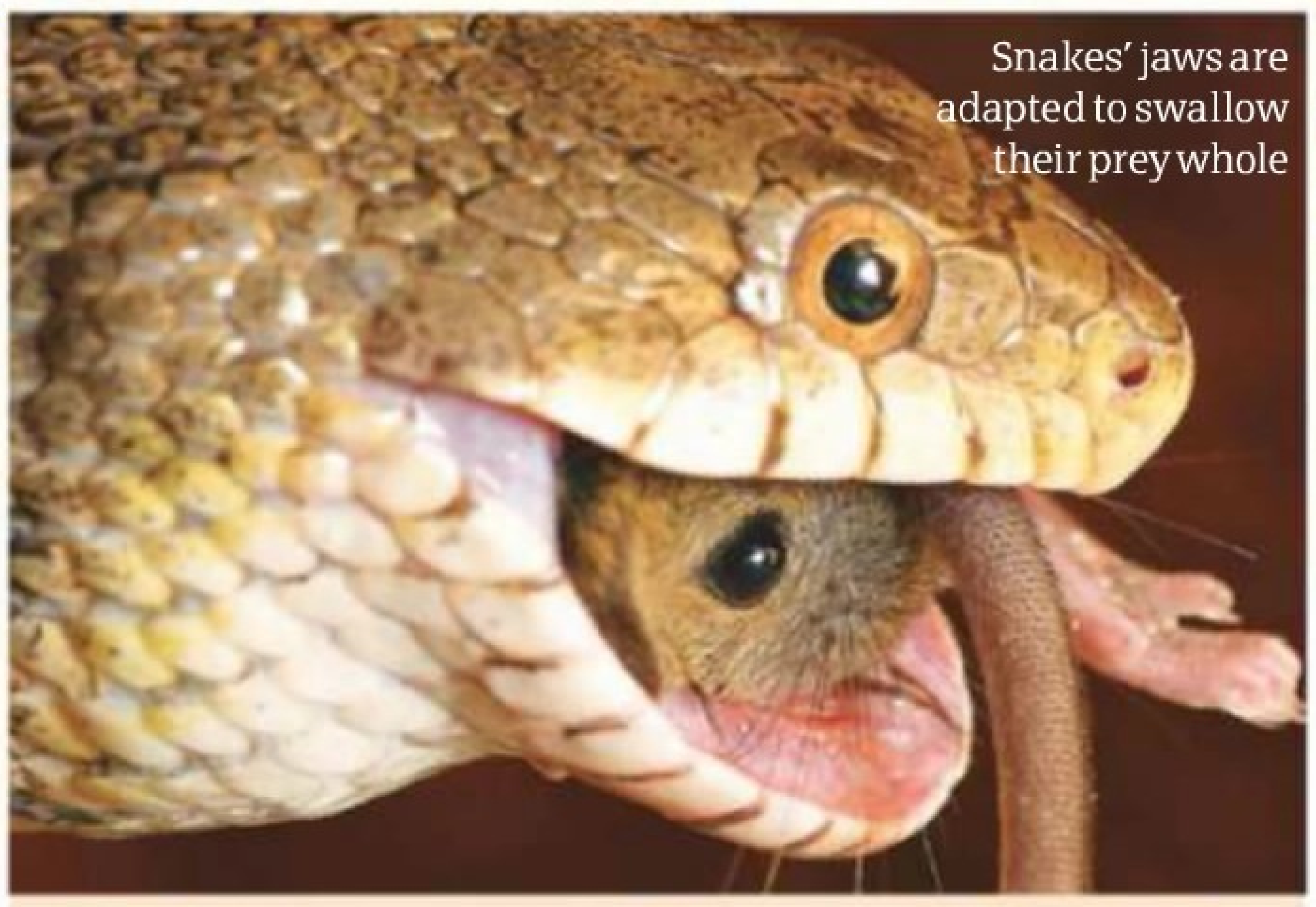
Snakes

Feared and respected in equal measure throughout human civilisation, discover the incredible life of snakes

Snakes are not legless lizards. They evolved from lizards about 112 million years ago but have since changed their body shape and habits quite radically. Modern legless lizards, like the slow worm and grass lizard, have short bodies and long tails, but snakes are nearly all body with a relatively short tail on the end. This means that the skeleton of a snake has ribs running for most of its length. Snakes also lack eyelids and external ear holes. Their eyes are protected by an unblinking, transparent scale called a brille and their poor hearing is made up for by their other senses. Snakes can smell the air by collecting molecules on their forked tongue, then passing them back to the Jacobson's organ at the front of the mouth. They can also sense vibrations through the ground and some species have 'thermal imaging' that enables them to detect the infrared radiation from live prey, even in complete darkness. The coral snake (aipysurus laevis) has light receptors in its tail, so that it can check it hasn't left the tip poking out, when it hides in a dark crevice.

Snakes have scales to conserve moisture and allow them to grip the ground. These aren't loose, like feathers or skin, but are anchored to the deep layers of the epidermis. When a snake moults, it sheds the entire skin in one go. Moulting isn't to allow room for growth (as with insects), but a way of replacing worn scales and getting rid of parasites.

You can find snakes in tropical seas and on every continent except Antarctica, but there are a few islands that they have never conquered, including Iceland, New Zealand and, perhaps most famously, Ireland.



Snakes' jaws are adapted to swallow their prey whole

How snakes hunt

Snakes attack with a fast lunge and a single bite. Their jaws and teeth aren't strong enough to take bites out of their quarry so they must swallow everything whole. Small, non-venomous snakes will strike for the head of a mouse or frog and either try to crush its skull or asphyxiate it by engulfing its mouth and nose.

Venomous species will strike and withdraw to avoid injury while the venom takes effect. Boas and pythons use their muscled bodies to constrict. This doesn't kill by crushing; the coils slide past each other so that the scales act as a ratchet. As the victim struggles, they can only tighten further. Sometimes the prey will die of asphyxiation, other times the pressure in the chest cavity becomes so immense that their heart simply stops.

Snakes don't actually dislocate their jaws to swallow large prey, but the lower jaw is very flexible and has some extra joints at the back of the skull to allow it to 'hinge' open extra wide. The left and right halves of the lower jaw aren't joined and so can 'walk' down an animal, drawing it into the serpent's mouth as they go.

THE STATS
SUPER SERPENTS

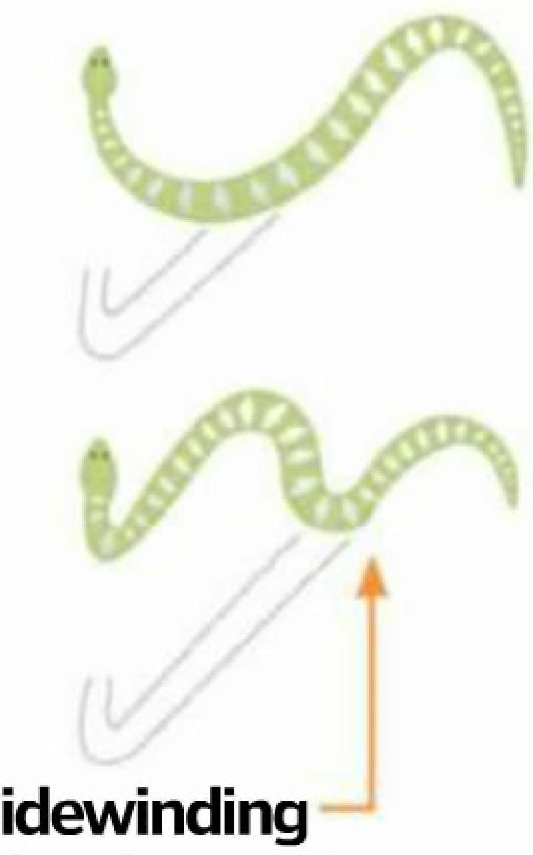
LARGEST PREHISTORIC	15m	MOST DEADLY	Indian Cobra	LARGEST PREY	Capybara
LARGEST VICTIM	Elephant	VENOM DOSE	100-400mg	TOP SPEED	19km/h

DID YOU KNOW? *Even a severed snake head can still bite and will automatically inject the maximum dose of venom!*

Getting around

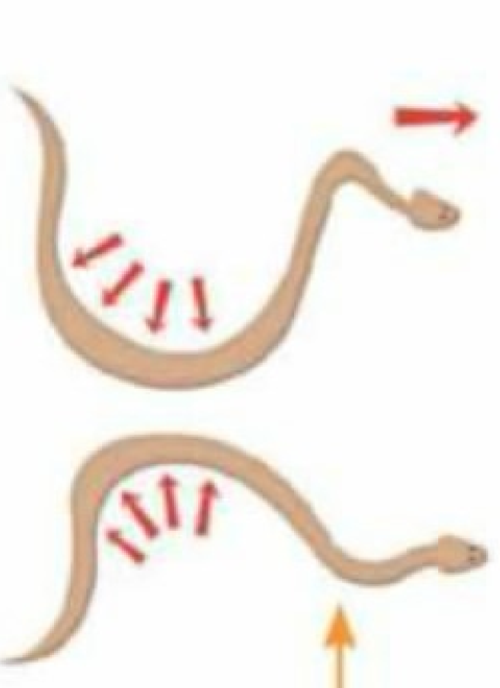
With no legs, snakes have developed some clever ways to get from A to B

Snakes have many ways of propelling themselves forward, depending on their environment. These use completely different muscle sequences and are much more distinct than, say, the differences between walking and running. All snakes can use lateral undulation but each species has other techniques unique to its habitat. Sea snakes, for example, can use lateral undulation to move backwards, while the chrysopelea snakes of Southeast Asia can even flatten their body into a gliding wing and launch themselves up to 100 metres (328 feet) from one tree branch to another.



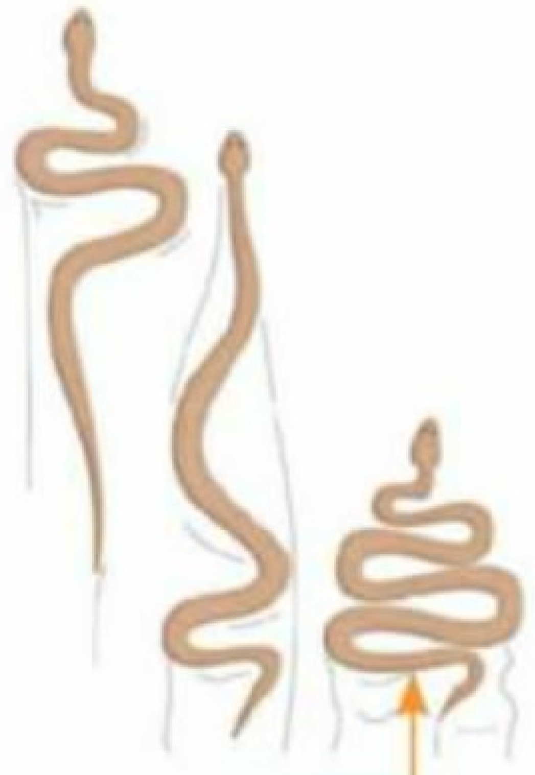
Sidewinding

Sidewinding is an adaptation to loose or slippery surfaces, so the contact points between the snake and the ground don't slide backwards. This maximises grip and uses less than one-third of the energy of a lizard which is running the same distance.



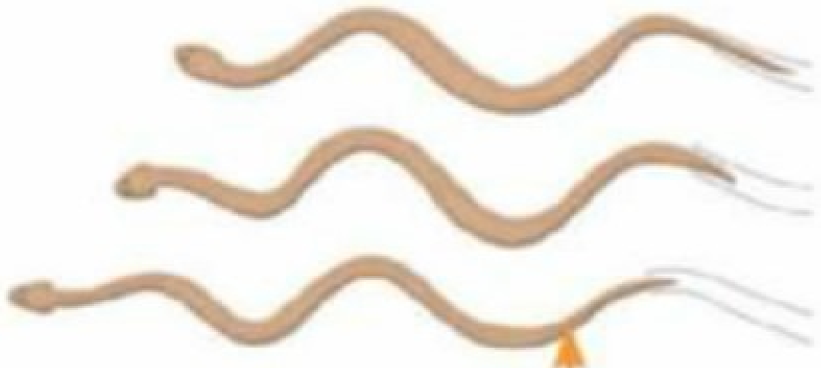
Slide pushing

In tunnels, there's no room to move side to side, so the snake alternately braces against the tunnel walls and stretches its body forwards. It's slower than lateral undulation and uses seven times more energy, but it's still faster than rectilinear movement.



Concertina

The snake pulls its body into a tight series of coils and then braces the tail section as it straightens out again. This needs good grip or something to push against, and it isn't efficient for long distances, but it's a quick way to lunge forward when striking.



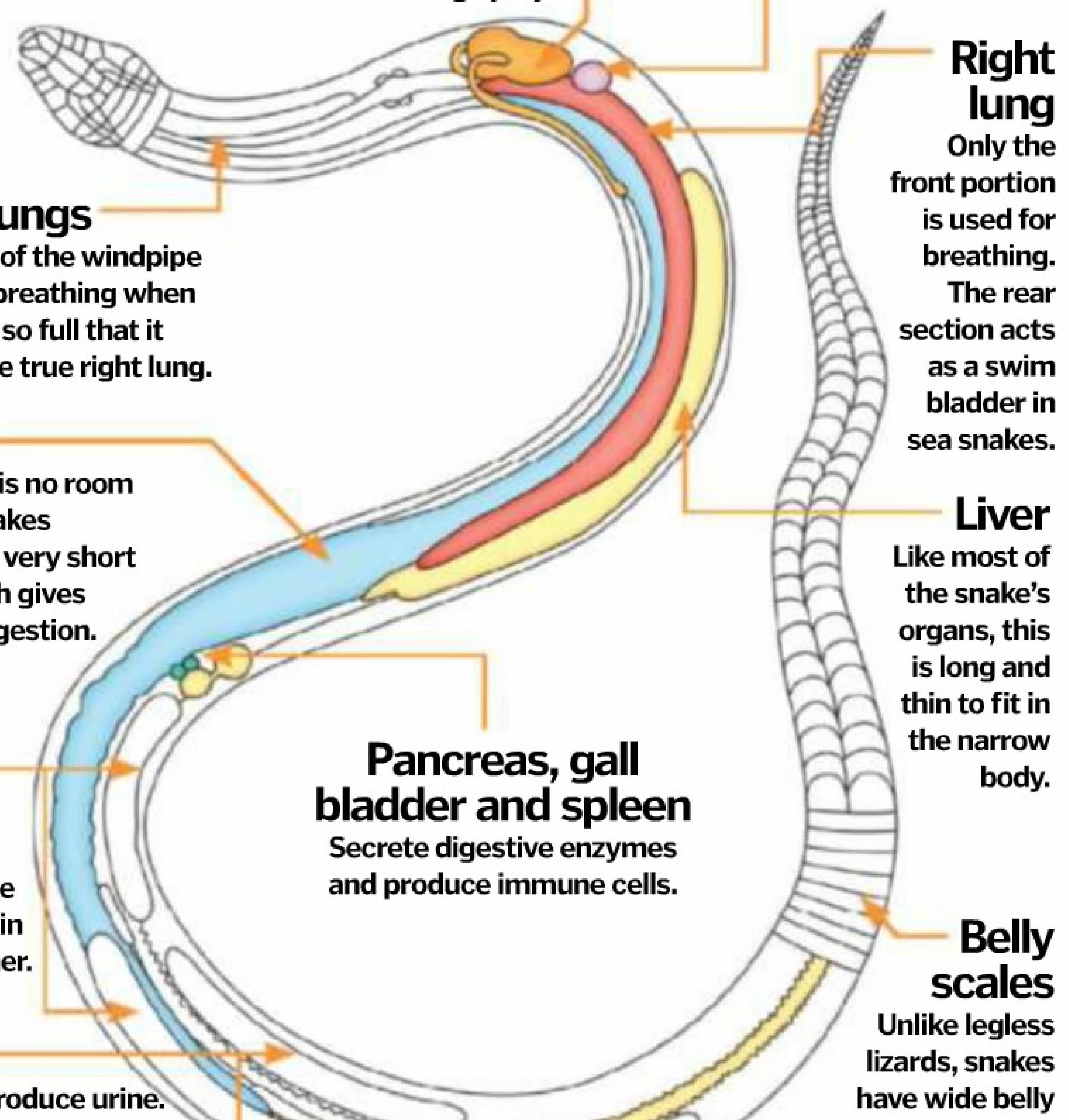
Lateral undulation

The most common form of locomotion involves the snake gripping obstructions or small irregularities on the ground with the side of its body, and rippling a wave down their length that slides past the obstruction. Aquatic snakes swim like this by pushing against the water itself.

Rectilinear

The slowest way to move uses the tiny muscles that attach the skin to the ribs. By alternately pulling the skin up off the ground and putting it down again slightly forward, the snake creates a travelling wave that creeps it forward almost silently. This form of movement is employed by pythons and boas when stalking prey.

The anatomy of a snake



Heart
Snakes have no diaphragm, so the heart is free to move out of the way when swallowing large prey.

Left lung
Shrunk to almost nothing to save space, the left lung isn't used for breathing.

Right lung
Only the front portion is used for breathing. The rear section acts as a swim bladder in sea snakes.

Tracheal lungs
This extension of the windpipe allows limited breathing when the stomach is so full that it compresses the true right lung.

Intestine
Because there is no room to coil it up, snakes actually have a very short intestine, which gives them a slow digestion.

Liver
Like most of the snake's organs, this is long and thin to fit in the narrow body.

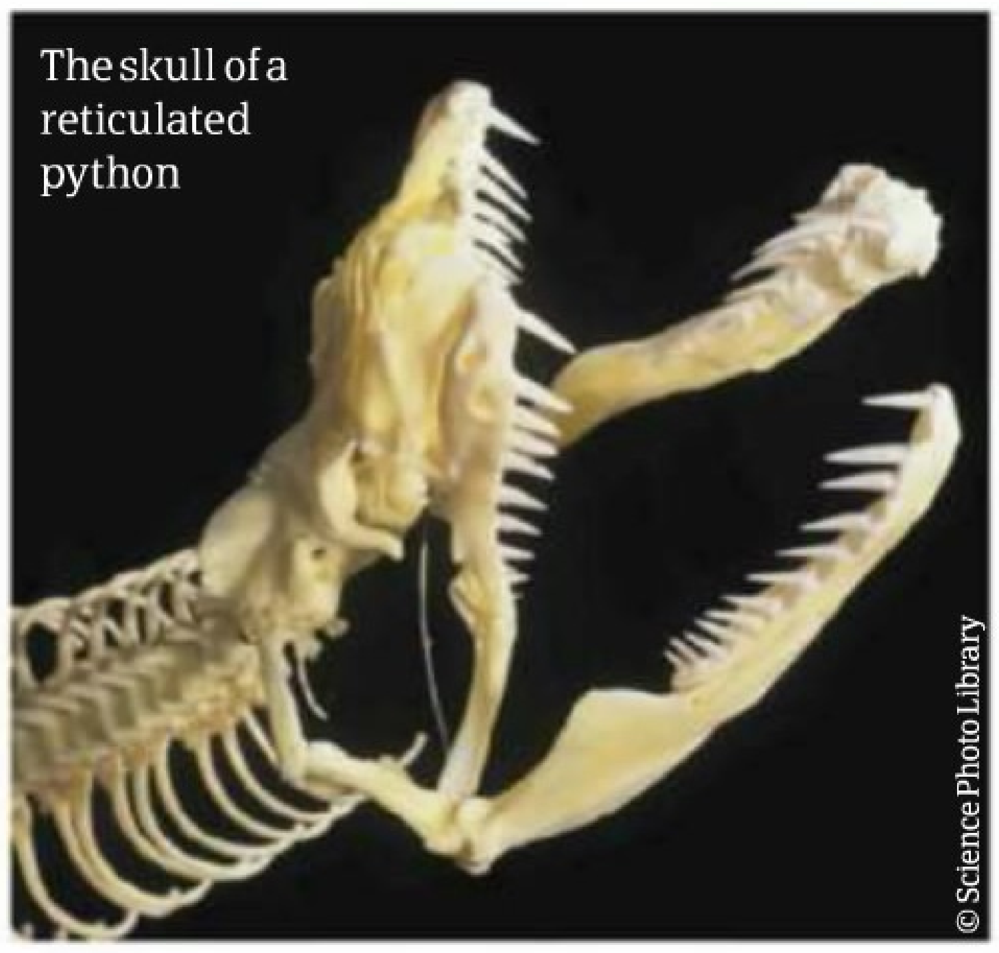
Testes
Where snakes retain paired organs, they are staggered one in front of the other.

Pancreas, gall bladder and spleen
Secrete digestive enzymes and produce immune cells.

Belly scales
Unlike legless lizards, snakes have wide belly scales with just a single column of scales on the underside.

Kidneys
Snakes don't produce urine. Instead they excrete uric acid, which is a dry white paste and lets the snake conserve water.

The snake uses its tongue to smell by bringing air molecules into contact with the Jacobson's organ



The skull of a reticulated python

© Science Photo Library

A deadly cocktail

2,900 species of snake have been indentified but only a quarter of them are venomous. Out of those, 250 species are deadly enough to kill a human with one bite and around 100,000 people are killed by snakebites worldwide each year.

Snake venom is produced in modified salivary glands and stored in reservoirs behind the eyes. Snakes can choose the dose they deliver with each bite and will sometimes 'dry bite' without injecting at all. Each species has a different venom that is a mixture of hundreds or thousands of different proteins and enzymes. Between them, they can affect every organ system in the body if left unchecked.

MAIN SYMPTOMS

- Rubbery, minty or metallic taste in the mouth
- Fear and panic
- Vomiting
- Diarrhoea
- Dizziness and fainting
- Severe pain
- Blurred vision
- Convulsions
- Rapid, weak pulse
- Spontaneous bleeding
- Numbness
- Breathing difficulty
- Tissue necrosis
- Heart failure

Why do snakes shed their skin?

How and why do these slippery reptiles moult so frequently?

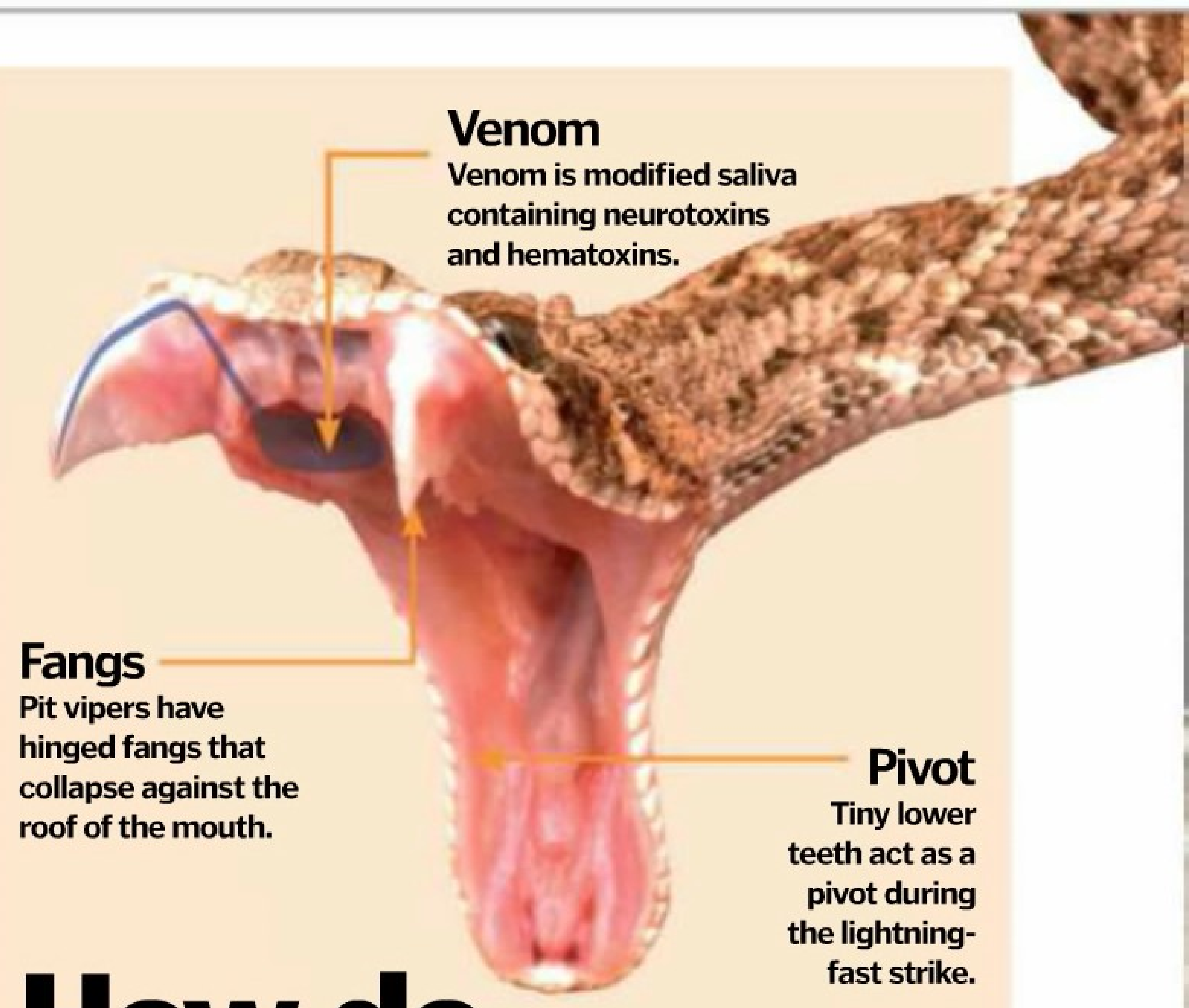
Snakes shed their skin for two main reasons. The first is to facilitate continued growth. This occurs as snakeskin does not grow in partnership with the snake itself, unlike in humans, where millions of skin cells are shed each year continuously on a microscopic, unseen level. On the contrary, snakes cannot shed skin in this microscopic way, necessitating them to literally outgrow the outer layer of skin whole on a frequent basis. The frequency that snakes shed their skin is largely dependent on the stage of life cycle they are in, with sheddings incredibly frequent during infancy and teenage years (bi-monthly in some species), but slowing to a couple of times per year as adults.

The second reason why snakes shed their skin is to preserve their health. Poor living conditions (lack of humidity, lack of vegetation, excess heat, and so on) as well as an inadequate food source can lead to skin damage and parasites. If left unchecked for a long period of time in the wild, this would be highly detrimental to the snake's well being. By shedding its skin, the snake can mitigate these potentially damaging conditions and start anew.

Interestingly, however, the shedding process brings with it complications. For the week or two preceding the shedding, the snake's vision is impaired due to the loosening of the skin's outer layer, and the week or two after the event, the new outer layer is soft and vulnerable to attack from predators. For this reason, snakes tend to be overly protective around sheddings, and largely inactive if possible. The snake initialises each shedding by rubbing itself against a sharp object such as rock, to pierce the outer layer of skin.

A close-up view of a snake's shedded skin

© Mylittlefinger



Venom
Venom is modified saliva containing neurotoxins and hematoxins.

Fangs
Pit vipers have hinged fangs that collapse against the roof of the mouth.

Pivot
Tiny lower teeth act as a pivot during the lightning-fast strike.

How do snakes bite?

Call them cold-blooded, but they have death down to a science

Snakes are highly adapted killers. Non-venomous snakes kill by constriction (suffocation) or swallowing prey alive. Venomous snakes – which make up only ten per cent of the world's snake species – inject their victims with powerful toxins that either paralyse the respiratory system or attack red blood cells, instantly rotting flesh and bone.

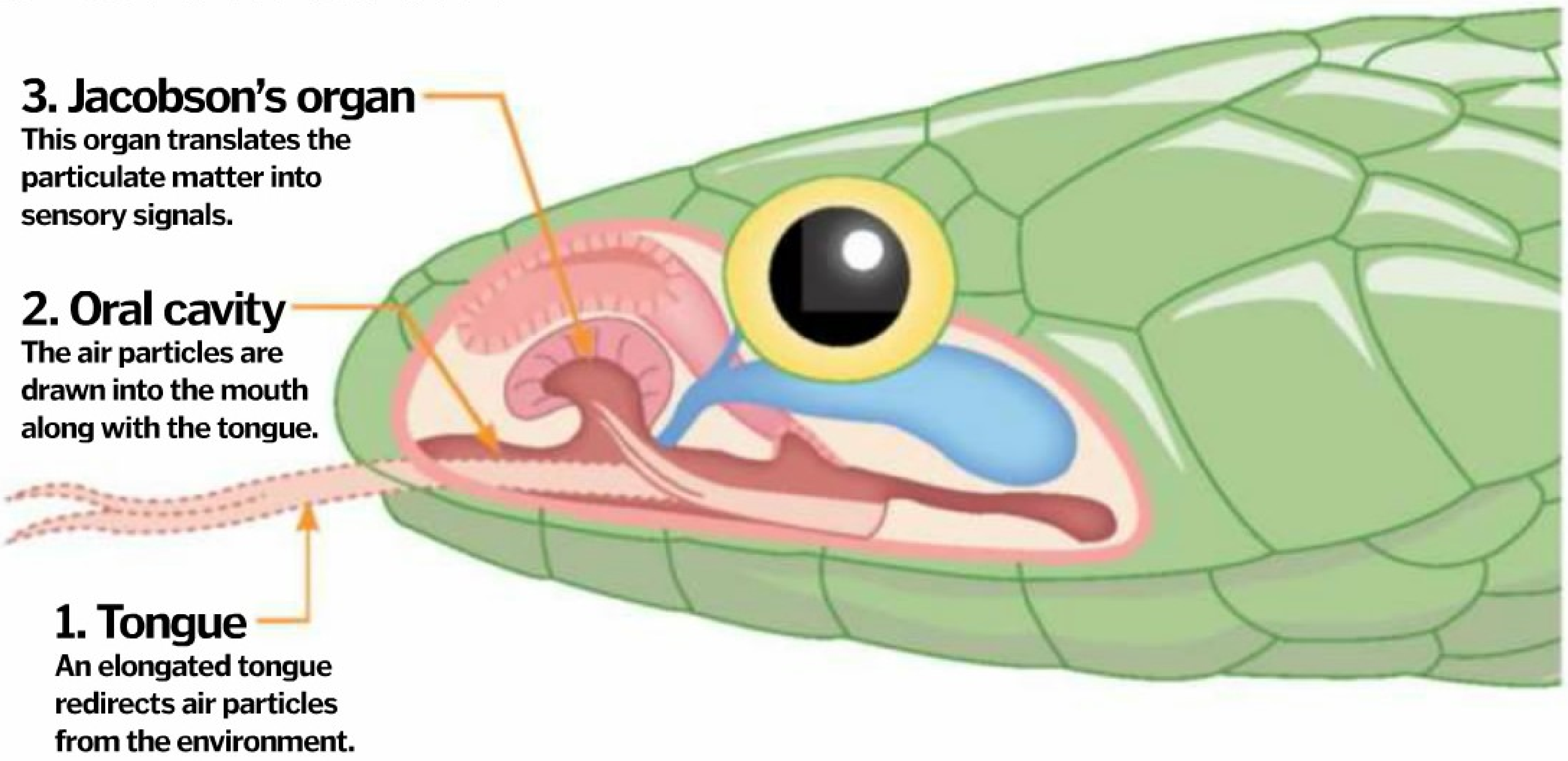
Only venomous snakes have fangs, a set of long, hollow teeth in either the front or back of the mouth that act as hypodermic needles. As fangs enter the flesh, the snake flexes its jaw muscle, squeezing toxic saliva out of the venom gland, through the fang's venom canal and deep into the victim's tissue.

Snakes can control the release of venom, so many defensive strikes against humans are non-lethal 'dry bites'. If bitten, never try to cut open the wound or suck out the venom. Keep the victim calm and get to a hospital quickly for a dose of antivenin.

How do snakes smell?

Nose not work? No problem!

While snakes have both nostrils and nasal cavities, they do not use them to smell with. In fact, snakes smell through the combination of a specialised organ located in their oral cavity and a flicking motion of their elongated tongue. The organ in question is referred to as the vomeronasal organ (or Jacobson's organ) and is located in the roof of their oral cavity. Due to its internal positioning, the snake utilises its forked tongue to flick air particles from the surrounding environment into contact with it. From here the vomeronasal organ translates the smell into electrical signals to be sent to the snake's brain, enabling it to determine whether prey or predators are in its locale. In addition, due to the tongue's role as a smelling device, it is not used by snakes to aid the swallowing process.



3. Jacobson's organ
This organ translates the particulate matter into sensory signals.

2. Oral cavity
The air particles are drawn into the mouth along with the tongue.

1. Tongue
An elongated tongue redirects air particles from the environment.

5 TOP FACTS PYTHONS

Record breaker

1 The longest python recorded was a reticulated python called Fluffy. Although native to SE Asia and the East Indies, Fluffy lived at a zoo in Ohio, USA, and measured a whopping 7.3m (24ft).

The pits

2 Before killing their prey through constriction, pythons seek out their warm-blooded dinner with special heat-sensing pits located in their mouths, between their eyes.

Mini me

3 Pythons can lay up to 100 eggs at a time – usually in the vacated burrows of other animals. The baby pythons are born alive and look just like miniature versions of their adult counterparts.

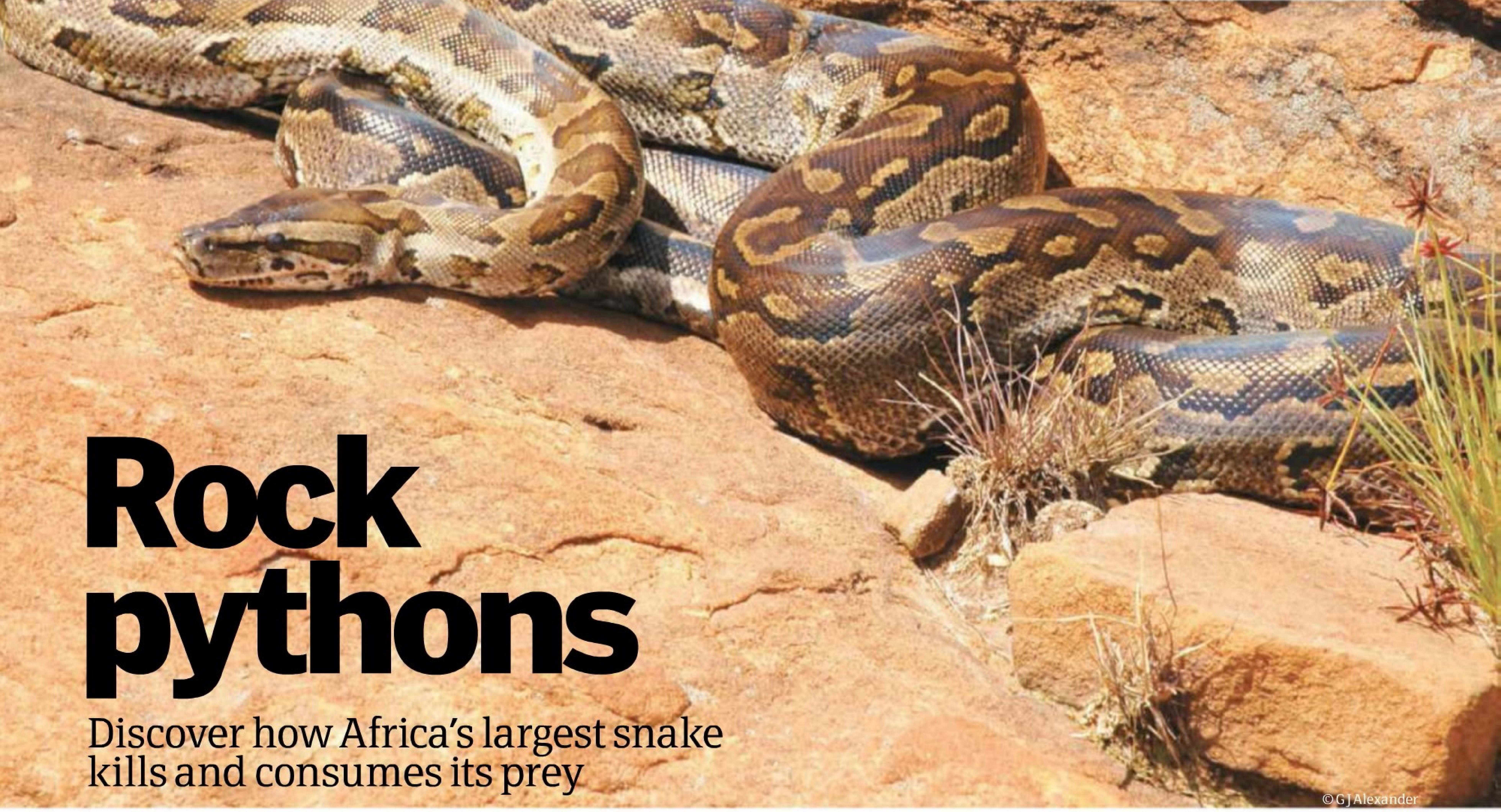
Pythons can swim

4 There are some 30 different species of python, all of which are good swimmers. Most species are ground-based, but some climb trees while others burrow underground.

Vestigial hind limbs

5 Like boas, pythons possess visible pelvic spurs, which are the evolutionary remnants of back legs. These tiny bones towards the tail end suggest they descended from lizards.

DID YOU KNOW? *The African rock python is a protected species which plays a vital role in controlling rodent populations*



© G J Alexander

Rock pythons have a diverse diet which includes everything from small antelopes to crocodiles

© SPL

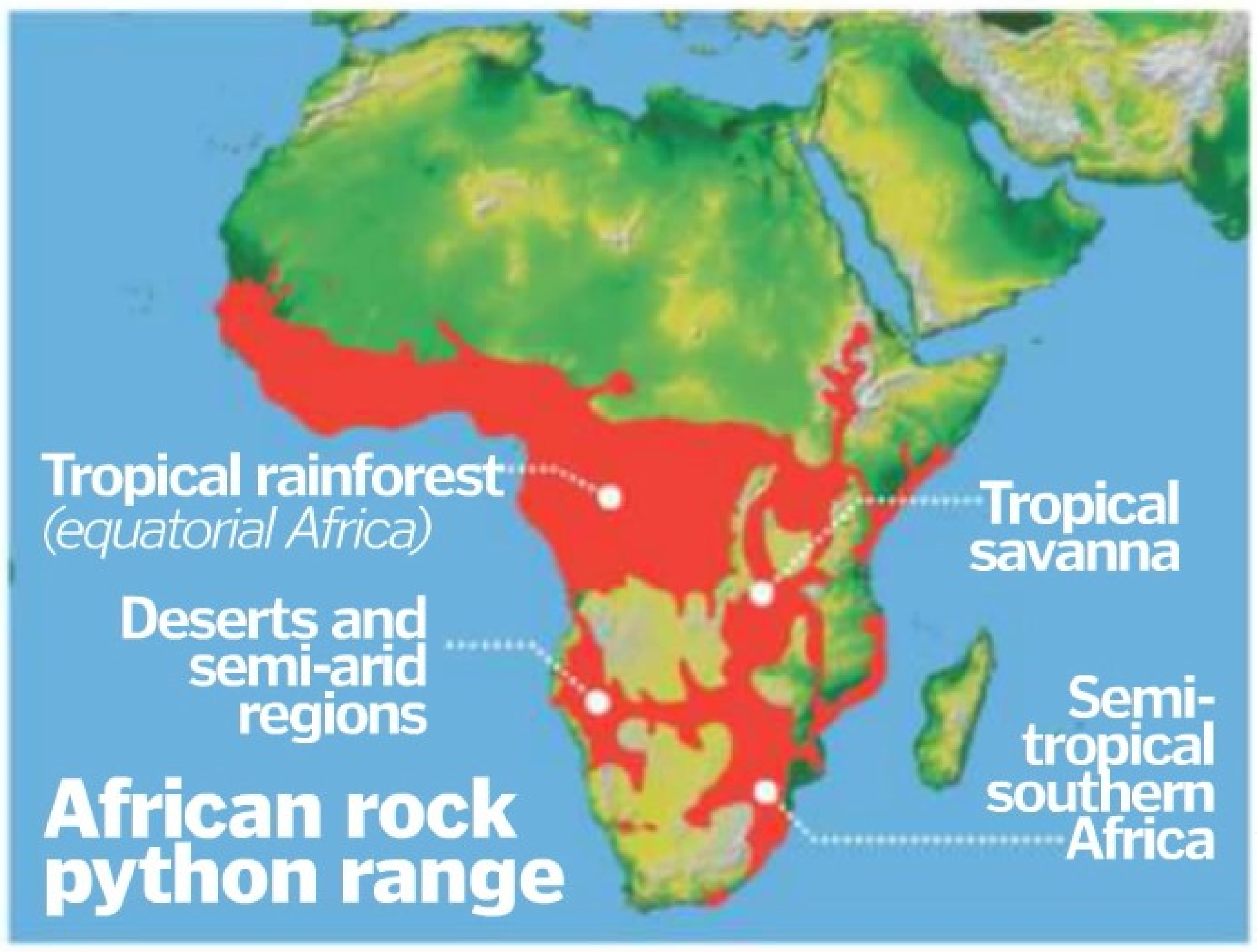
Rock pythons

Discover how Africa's largest snake kills and consumes its prey

Despite being non-venomous, the python remains one of the world's most dangerous serpents. The African rock python, in particular, is a very deadly assassin, also notorious for being ill-tempered.

Pythons incapacitate their prey by literally squeezing the life out of them, coiling their long – sometimes seven-metre (23-foot) – bodies round the victim and tightening their grip until the animal, unable to breathe, eventually suffocates. That done, the python then sets about consuming their meal… in one go.

Equipped with a set of highly flexible jaws, stretchy skin and ribs hinged with extra-supple tissue, the African rock python can down its quarry whole. First the python slides its mouth over the head of the prey and then gradually moves its body along the length of the animal with the help of an expandable throat and abdomen. The animal is then digested over a matter of hours, or even days if it's particularly large. Following such a meal, the python need not eat again for several weeks.



Tropical rainforest (equatorial Africa)
Tropical savanna
Deserts and semi-arid regions
Semi-tropical southern Africa
African rock python range

© NASA

The statistics…

© Tigerpython

Rock pythons

Type: Reptile

Genus: Python sebae

Diet: Carnivore

Life span in wild: Up to 25 yrs

Weight: Up to 100kg (220lb)

Size: Up to 7m (23ft)

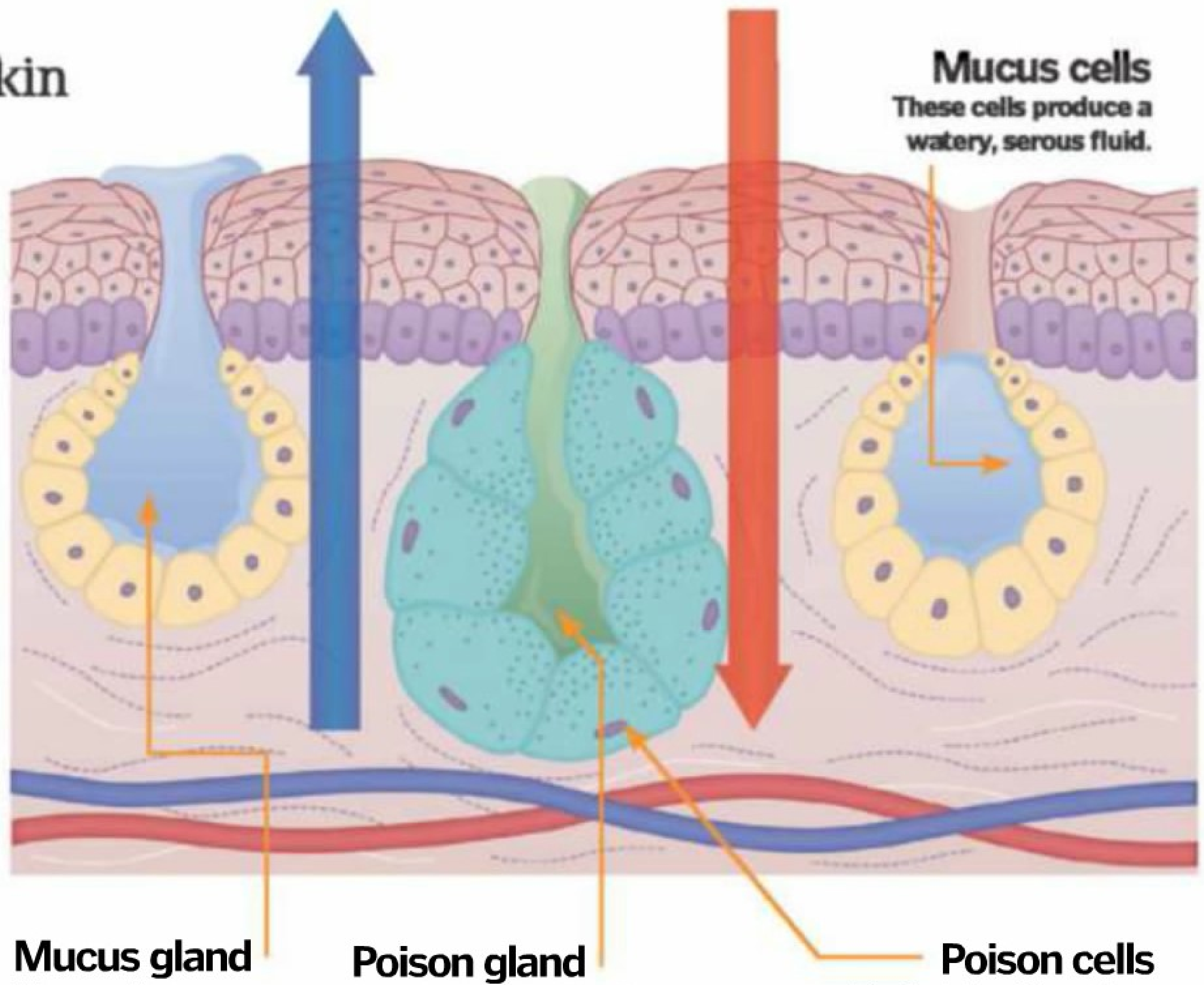
Amphibian skin

Skin is the body's main protective barrier against the outside world, and although an amphibian's skin is only very thin it has many qualities vital to keeping amphibians alive

Amphibians can breathe in and out through their skin – both on land and under water – and they can take in water not through their mouths but instead through absorbent skin found on their underside, called a seat patch. Most adult amphibians do have lungs, but additional oxygen is taken in through the skin to supplement that provided by these organs. Some species of salamander have no lungs or gills and breathe exclusively through their skin.

The reason that amphibians feel slippery is that their skin is full of glands that produce mucus, which spreads across the surface of the skin. This mucus moistens the skin, making it softer and therefore more oxygen absorbent. Although amphibians have few defences against predators, they do have additional poison glands on their skin that secrete irritating toxins for repelling would-be diners. Most are only mildly poisonous, but some species, such as the South American poison dart frog, are deadly to the touch.

Amphibian skin must stay moist in order to prevent the body from becoming too hot or cold, and also to avoid the risk of desiccation (drying up), which would spell the end for Mr Toad. This constant need for moisture means that, as well as producing protective mucus, amphibians should live close to a water source.



Breathe out
Carbon dioxide leaves the body through the skin.

Breathe in
Oxygen passes into blood vessels via the skin.

Mucus cells
These cells produce a watery, serous fluid.

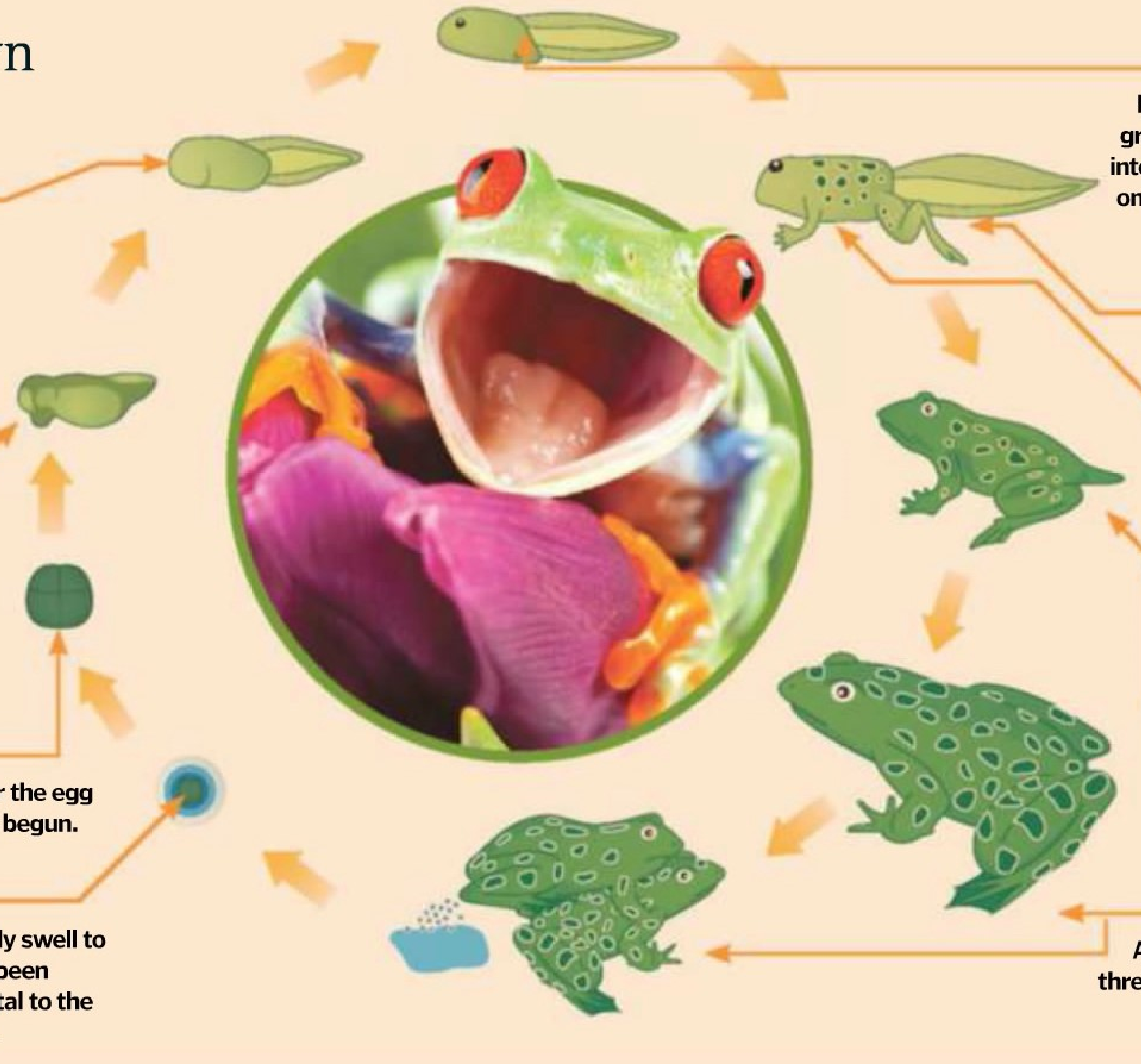
Mucus gland
Mucus cells group together to form a sac-like gland.

Poison gland
Groups of poison glands are located in areas most likely to be attacked by predators.

Poison cells
The toxicity of the poison secreted is reliant on the amphibian's diet.

The life cycle of an amphibian

The incredible journey from spawn to tadpole to frog



1. Egg
Several layers of absorbent watery jelly swell to protect a single tiny embryo that has been fertilised by the male frog. Water is vital to the development of these aquatic babies.

2. Mutation
Following a mere matter of hours after the egg has been laid, the metamorphosis has begun.

3. Tail bud
The tail bud forms at around the four-day mark. Muscles have begun to develop and the embryo feeds on the yolk inside itself.

4. Tadpole
At six days old, the egg hatches and becomes a tadpole. External gills develop to filter water and take in tiny bits of food. A sucker protrudes beneath the head end, which can suck onto plant matter.

5. Internal gills
Nine days into metamorphosis, a flap of skin grows over the external gills and replacement internal gills develop. A spiracle (pore) remains on the left-hand side where water can escape. The tadpole's eye is not yet fully formed.

6. Hind legs
Next the internal gills develop and a pair of hind legs form.

7. Front legs
The final stage of a frog's development (around 75 days) includes the arrival of front legs and lungs to replace the internal gills. Amphibians can also breathe through their mucous-covered skin.

8. Froglet
For the next one to two years, the young frog's tail will become increasingly short until it's barely a tail at all.

9. Frog
A frog becomes an adult at the tender age of three years. It will breathe using its fully formed lungs and will take to the land to seek out a mate and begin the whole process again.

Elastic energy in the leg muscles transforms into mechanical energy during the leap

How do frogs leap?

Discover what enables this amphibian to jump up to 50 times its own body length

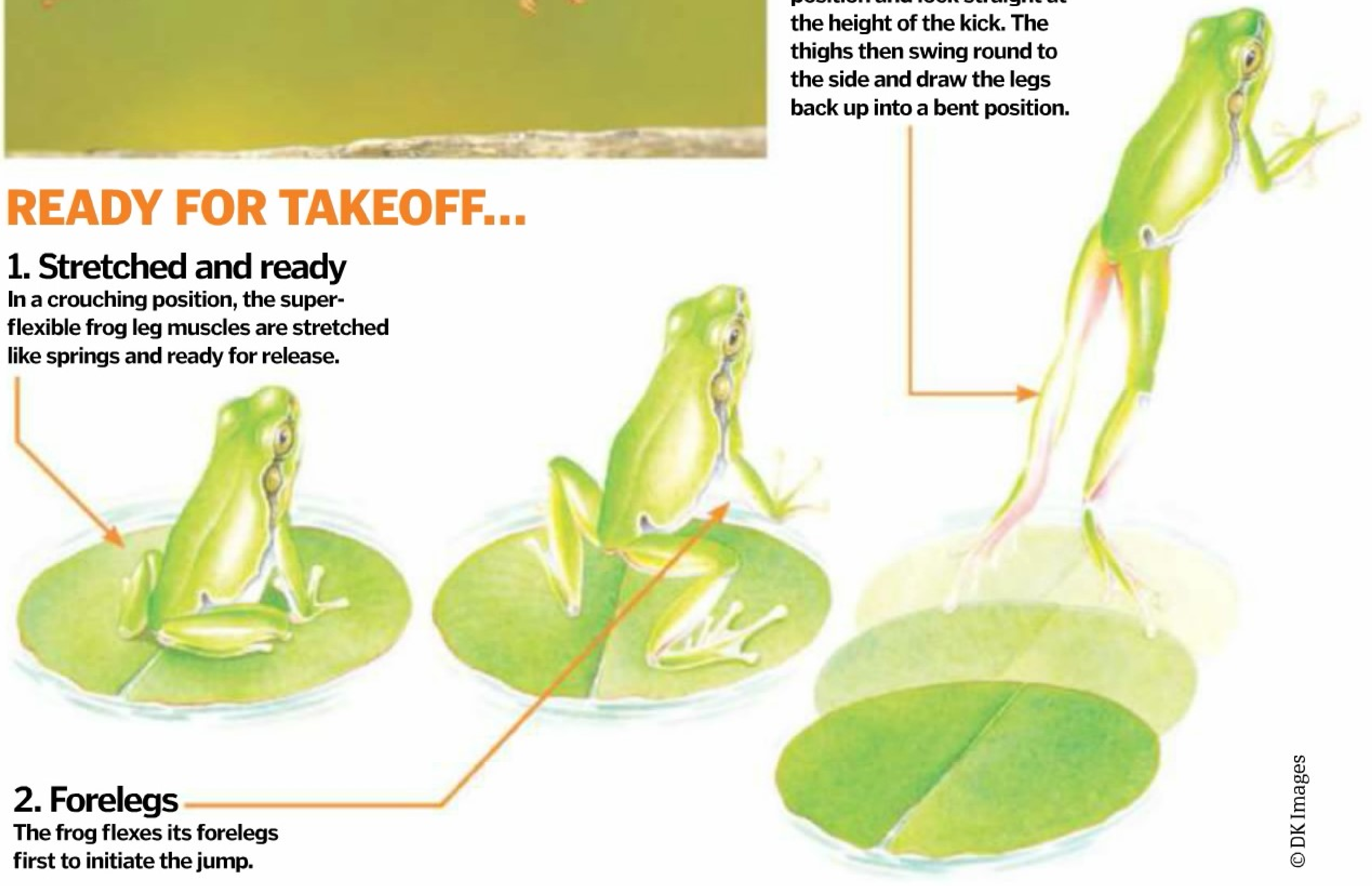
The secret to why frogs can jump so far is all in their legs. The ideal way for a frog to evade predators is to leap away in a split second. The amphibians have evolved extremely strong hind legs with specially fused leg bones and proportionally big feet, which are perfect for launching into the air over huge distances, as they enable the frog to push off against the ground for longer.

Using high-speed cameras to examine the anatomy of a frog as it jumps, researchers have discovered the mechanics of how a frog can travel so far. Pre-jump the muscles in a frog's powerful hind legs are lengthened and stretched as they sit in the typical crouching position. Upon takeoff the muscles connecting the pelvis to the knee contract as the frog flies into the air, pulling the upper hind leg backwards and propelling the frog forwards. The muscles then stretch again once the frog has reached the ultimate height of its jump. These super-stretchy muscles store a huge amount of elastic energy, which in turn is transferred into mechanical energy.

The appropriately named rocket frog can jump a massive two metres (6.6 feet) – that's over 50 times its own body length. This is the equivalent of Olympic triple-jumper Jonathan Edwards jumping around 90 metres (295 feet) in just a single stride – let alone three.

One mighty leap can be the difference between life and death for a frog

READY FOR TAKEOFF…



1. Stretched and ready

In a crouching position, the super-flexible frog leg muscles are stretched like springs and ready for release.

2. Forelegs

The frog flexes its forelegs first to initiate the jump.

3. Hind legs

Simultaneously the hind legs extend to a vertical position and lock straight at the height of the kick. The thighs then swing round to the side and draw the legs back up into a bent position.

© DK Images

The life of turtles

Slow and steady wins the race as these armoured reptiles have proven across millions of years

The statistics...

Turtle

Type: Reptile

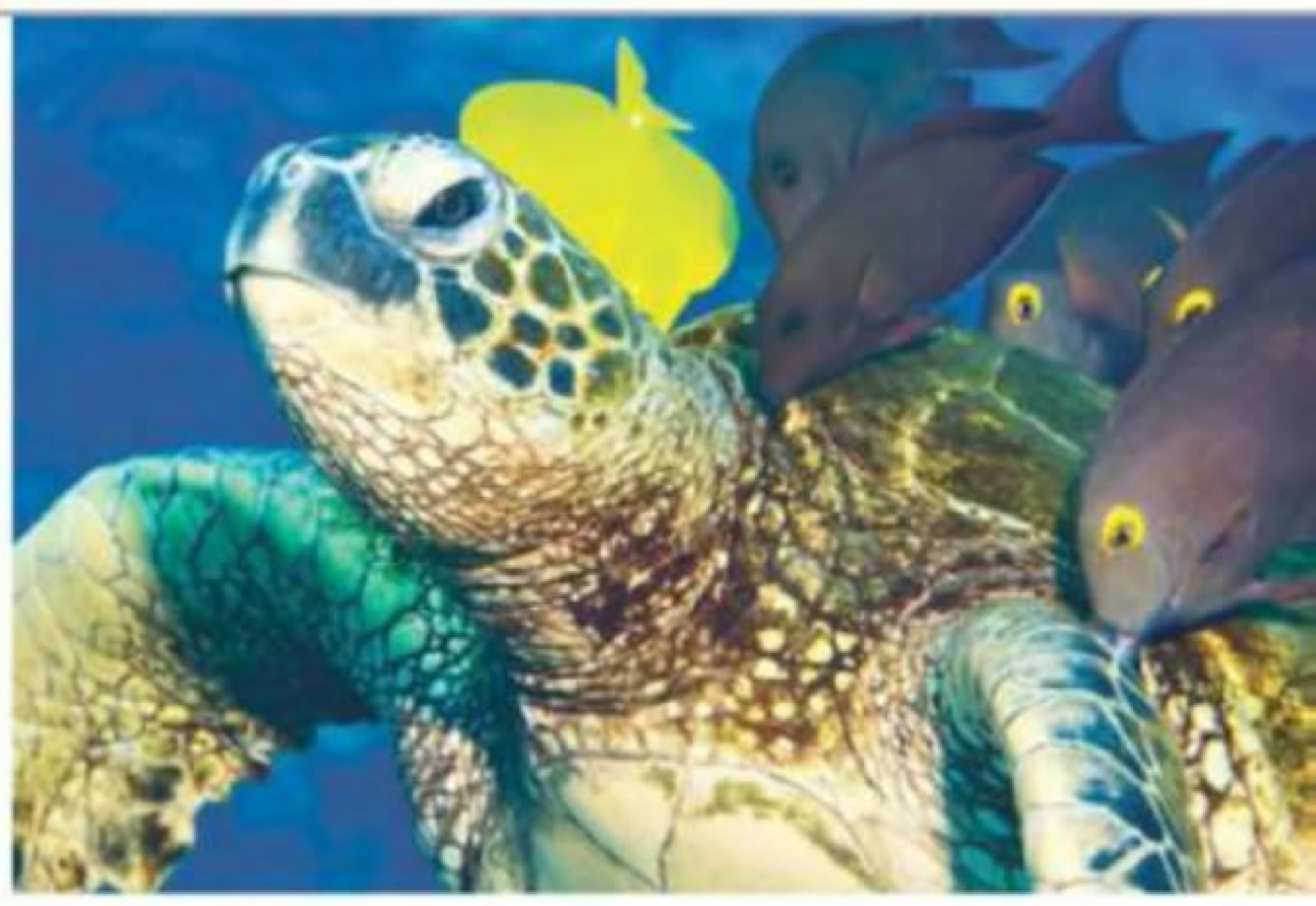
Genus: Chelonia

Diet: Varies by species, but generally omnivorous

Average life span in the wild: Typically from 50-100+ years

Weight: From 100g (3.5oz) to 900kg (1,984lb)

Size: From 5-10cm (2-4in) to over 2m (6.6ft)



Keeping clean

When you're covered by a shell and your flippers won't hold a scrub brush, you need a little help to stay clean. Over time, turtles can become covered with algae, ectoparasites and barnacles. Cleaner fish – notably wrasses, but also species, such as the pictured tangs – swim in to remove the debris, earning an easy meal in the process. Although this relationship is apparently mutualistic – ie beneficial to both creatures – there are concerns that cleaner fish may spread disease among turtles.

Baby hawksbill turtles make the most perilous journey of their lives as they crawl from their nest to the sea

One of the most notable things about turtles is their endurance. Arising over 100 million years ago, turtles have enjoyed a fairly stable existence, standing by as the dinosaurs rose and fell, and changing very little across the many millennia.

Specialised adaptations allow turtles to live in a diverse array of habitats. Many freshwater turtles must hibernate to survive the winter, slowing their metabolism down so far that they can go months without eating or drinking. On the other hand, the leatherback sea turtle speeds its metabolism up, enabling it to survive in water far too cold for any other reptile.

Some turtle species are territorial and may have dominance hierarchies, but they form no social bonds. Typically turtles come together only because they share habitat or for mating. Freshwater species tend to breed annually, whereas marine turtles may only reproduce every few years. Female turtles are capable of storing viable sperm in their oviducts for months, or even years! When ready to lay her eggs, she leaves the water and seeks a suitable substrate for digging on land. Freshwater turtles make nests in the soil along the waterways and ponds where they live. Marine turtles, on the other hand, travel widely over the course of a year, following ocean currents, but will swim hundreds, or even thousands, of miles in order to return to their natal beaches.

Once her eggs are buried, a female turtle's parental responsibilities are over. Incubation time varies by species and climate, but is around two to three months. When the baby turtles are ready to hatch they use a sharp egg tooth to cut through their shells and then, as a group, they dig their way out and make for the relative safety of the water. Marine turtles typically emerge at night and instinctively crawl en masse towards the brightest horizon which on a natural beach is towards the ocean.

Young turtles are vulnerable to dehydration, as well as a variety of predators; relatively few survive to adulthood. Even adult freshwater turtles may fall prey to animals such as raccoons or herons, but adult marine turtles have few natural enemies. Although the occasional shark or killer whale may attack, by far the biggest threat to marine turtles is humans. Thousands of turtles are injured by boats or killed in fishing nets each

RECORD BREAKERS
TURTLE TITAN

2,200kg

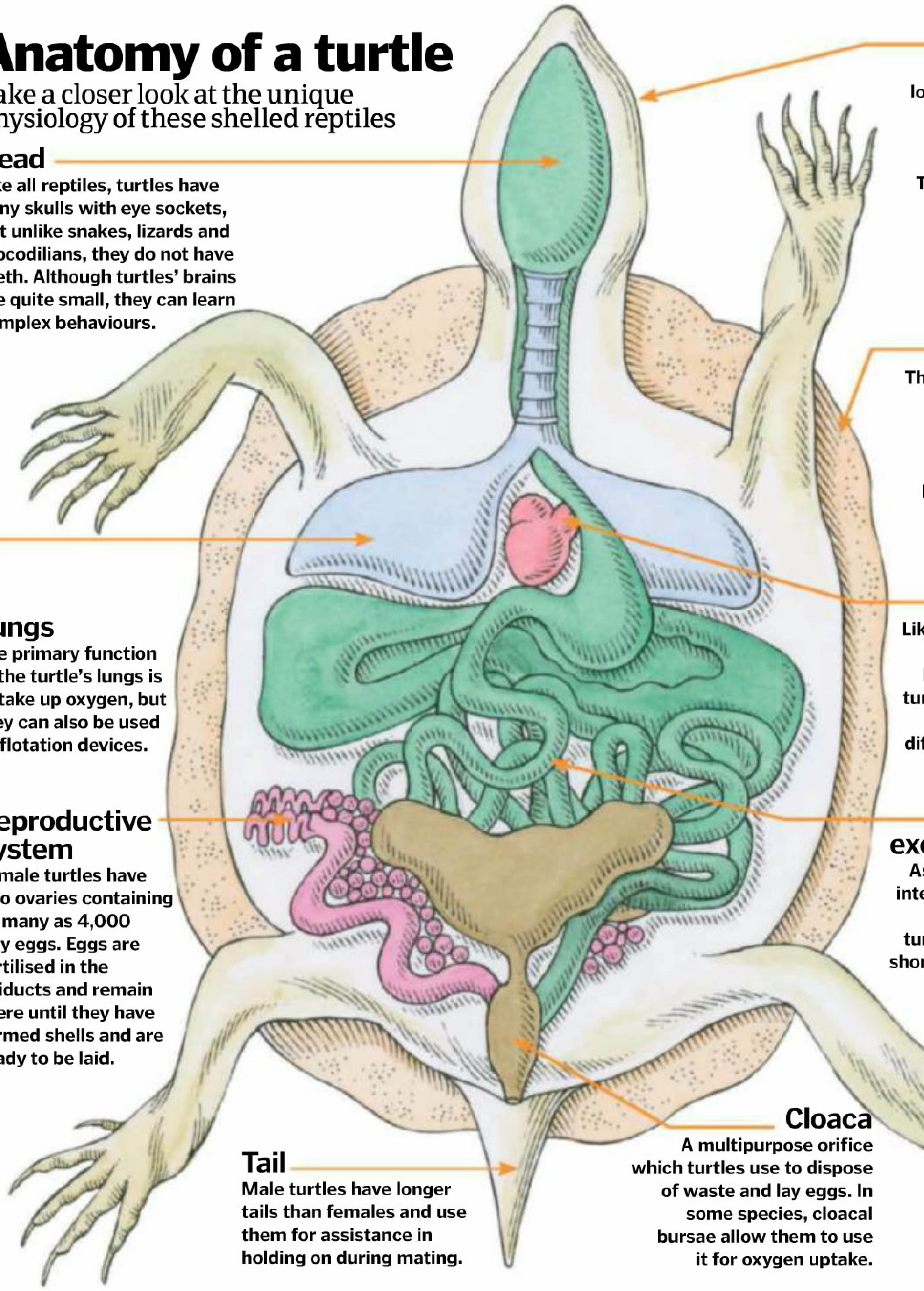
KING OF THE CHELONIANS

The largest turtle ever was a member of the genus archelon and an ancestor of modern leatherbacks. At over 4m (13ft) long and weighing 2,200kg (4,850lb), it was roughly the size of a large family car.

DID YOU KNOW? *In many species, the gender of a turtle is determined by the temperature at which the egg is incubated*

Anatomy of a turtle

Take a closer look at the unique physiology of these shelled reptiles



Head
Like all reptiles, turtles have bony skulls with eye sockets, but unlike snakes, lizards and crocodilians, they do not have teeth. Although turtles' brains are quite small, they can learn complex behaviours.

Lungs
The primary function of the turtle's lungs is to take up oxygen, but they can also be used as flotation devices.

Reproductive system
Female turtles have two ovaries containing as many as 4,000 tiny eggs. Eggs are fertilised in the oviducts and remain there until they have formed shells and are ready to be laid.

Tail
Male turtles have longer tails than females and use them for assistance in holding on during mating.

Eyes
Turtles have excellent low-light and colour vision and, in some species, the position of the eyes grants binocular vision. Turtles have eyelids and a tough transparent membrane that protects the eye when open.

Shell
The top of a turtle's shell is called the carapace, and the bottom is called the plastron. Most sea turtle shells are covered with hard scales called scutes made largely of keratin.

Heart
Like humans, turtles have a four-chambered heart. However, unlike humans, turtles possess two aortas, which deliver blood to different parts of the body.

Digestive and excretory systems
As with other reptiles, the intestines and bladder, plus the oviducts of female turtles, all discharge into a short tube called the cloaca.

Cloaca
A multipurpose orifice which turtles use to dispose of waste and lay eggs. In some species, cloacal bursae allow them to use it for oxygen uptake.

year, while others are hunted for their shells or meat, either for food or for traditional medicines.

Today these fascinating animals are among the most threatened in the world, with more than half of turtle/tortoise species facing extinction. All seven species of marine turtles are endangered or critically endangered, and the total populations of certain rare freshwater turtles number in the single digits.

> "Turtles will swim hundreds of miles to return to their natal beaches"

An inner compass

Sea turtles are able to travel all over the world and yet many species somehow manage to find their way back to the beach where they hatched, sometimes laying their own eggs mere metres from the place where they emerged. Research indicates that many species use magnetic fields to create a mental map that pinpoints their current location relative to their goal, as well as providing them with a compass bearing. Exactly how they do this is unclear, but scientists have found tiny crystals of the mineral magnetite in turtles' brains, which are known to perceive magnetic fields.

Spot the difference

TURTLE

Habitat: Almost entirely aquatic, in the open ocean.
Shell: Teardrop shaped and streamlined, designed for speed in the water.
Mobility: Instead of feet, sea turtles have large flippers so they can 'fly' through the sea.
Size: Varies; some can be 75cm (29.5in), while others exceed 3m (9.8ft).
Diet: More likely to be carnivorous, eg crabs/shrimp.
Geographical distribution: Found in all oceans, but mostly in temperate areas.

TORTOISE

Habitat: Terrestrial but a few species are semi-aquatic when young.
Shell: High domed shell which is thicker and bumpier than aquatic turtles.
Mobility: With rounded, stumpy legs, tortoises are built to walk on land and dig in soil. They can't swim.
Size: Range from 6cm (2.4in) to 1.8m (5.9ft).
Diet: More likely to be herbivorous, eg grass/fruit.
Geographical distribution: Worldwide, from North America to Mediterranean.

TERRAPIN

Habitat: Fresh and brackish water.
Shell: Their shells are quite flat in comparison.
Mobility: Terrapins are more versatile between land/water.
Size: Generally smaller, but some can be tortoise sized.
Diet: Very much omnivorous.
Geographical distribution: Worldwide; the most common in terms of number of species.

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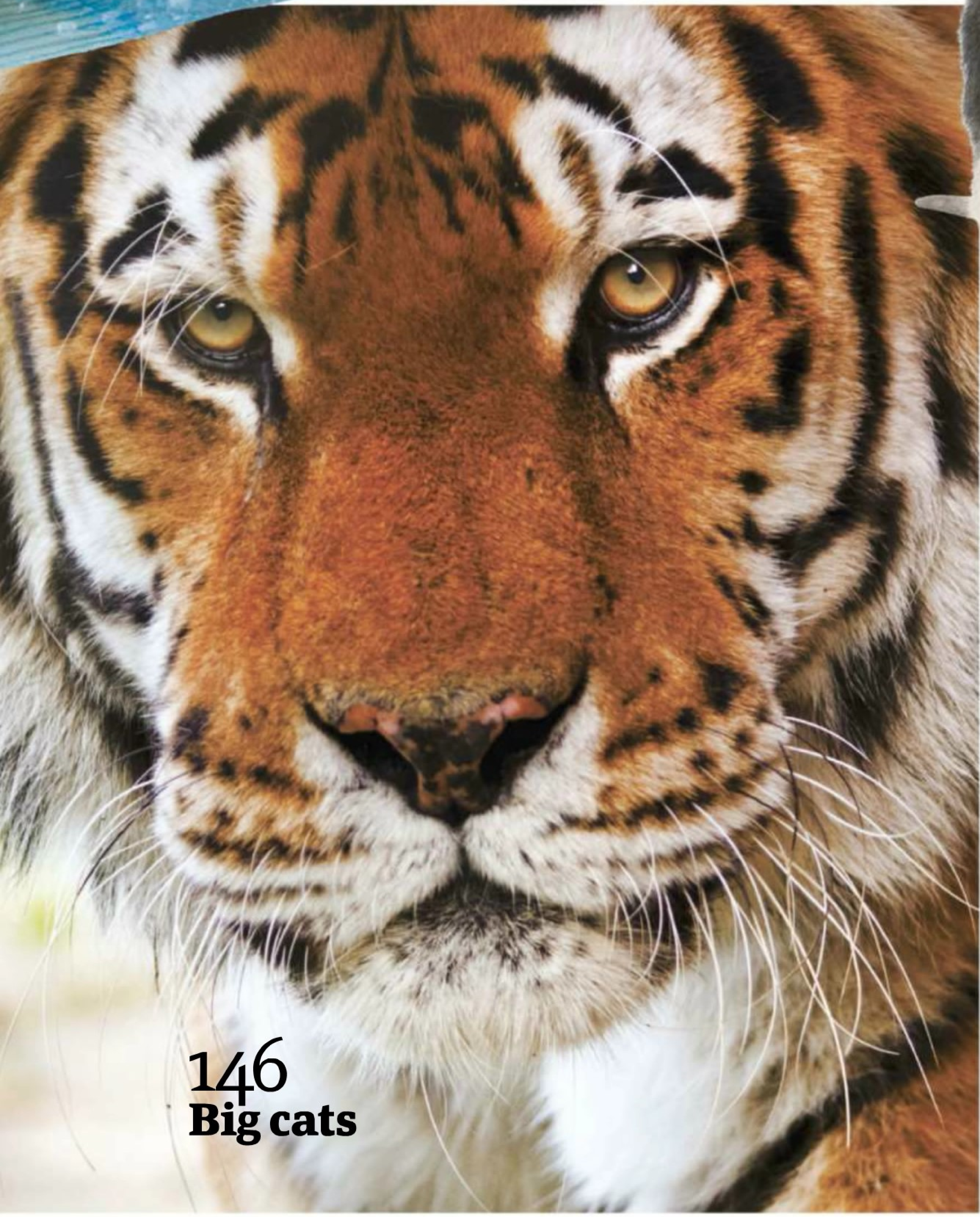

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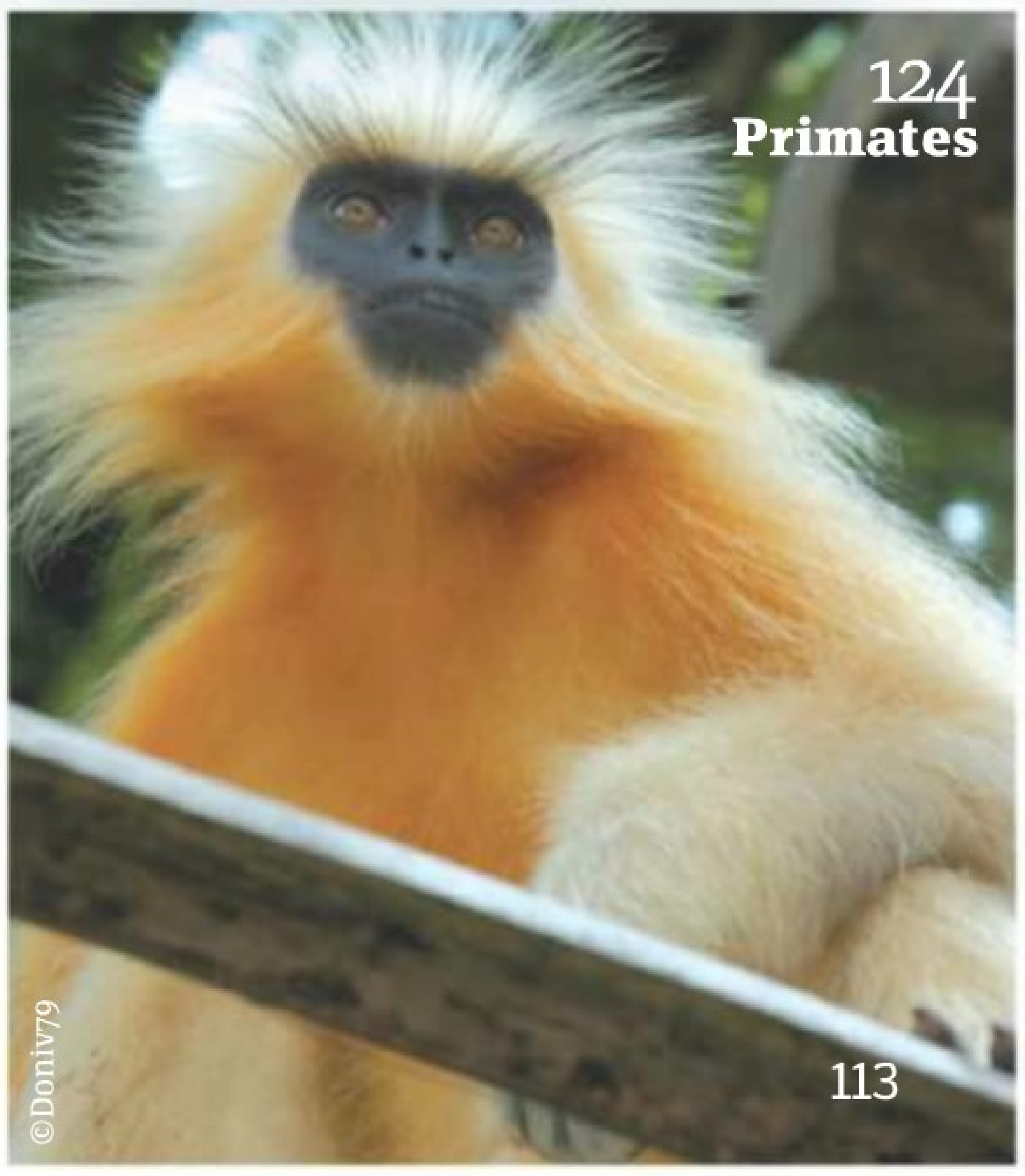

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Primates

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How whales communicate

Whales produce a wide range of complex sounds through differing techniques – we explore some of the mystery of whales' songs

Whales communicate by creating sounds through methods that differ depending on their family type. Toothed whales – which include dolphins – produce high-pitched sounds by the manipulation of air stored in their head through their phonic lips, a structure loosely akin to the human nasal cavity. As air is passed through the phonic lips they contract causing vibrations in the surrounding tissue before being consciously streamed by the whale.

Baleen whales differ in their sound creation, as they do not posses a phonic lip structure, doing so through manipulation of air passing through their larynx instead. The larynx works through the vibrations of internal vocal cords when air is passed over them. However, mystery shrouds this method of communication as baleen whales lack vocal cords, so presently scientists are unsure as to the exact manner in which their low-pitched sounds emanate from their larynx.

How do blowholes work?

Find out why marine mammals have a little hole on top of their heads

Whales, dolphins and porpoises are all cetaceans and spend their whole lives underwater. Unlike fish however, which have gills, cetaceans are mammals and so have lungs. They therefore need to come to the surface now and then to take in oxygen. The blowhole is a small nostril-like opening located on the dorsal side of the mammal near its head. It enables the animal to take in air without having to stop and lift its mouth out of the water.

A muscular flap covers the blowhole and remains sealed when the creature is relaxed so the lungs don't fill with water. When the animal contracts this flap, the blowhole opens enabling the creature to exhale and take in another breath.

Sperm whales can hold their breath for over an hour. When the whale comes to the surface, air and waste gases are forcefully expelled from the lungs. As this warm, moist air is released, the water vapour condenses and emerges from the blowhole as a misty spout.

All images © SPL

How sperm whales dive

With a diving range of up to a kilometre, how does this animal plunge to such mighty depths?

Native to all the world's oceans, the sperm whale is one of the largest predators that still hunts individual prey, such as giant squid and octopus, which it dives to immense depths of up to 1,000 metres (3,280 feet) to find. While using echolocation to track down its next meal is a fine talent in itself, descending to these great depths is another matter entirely. So how does it do it?

The statistics...

Sperm whale

Type: Mammal

Genus: Physeter macrocephalus

Diet: Carnivore

Average life span in the wild: Up to 60 years

Length (male): 15-18m (50-60ft)

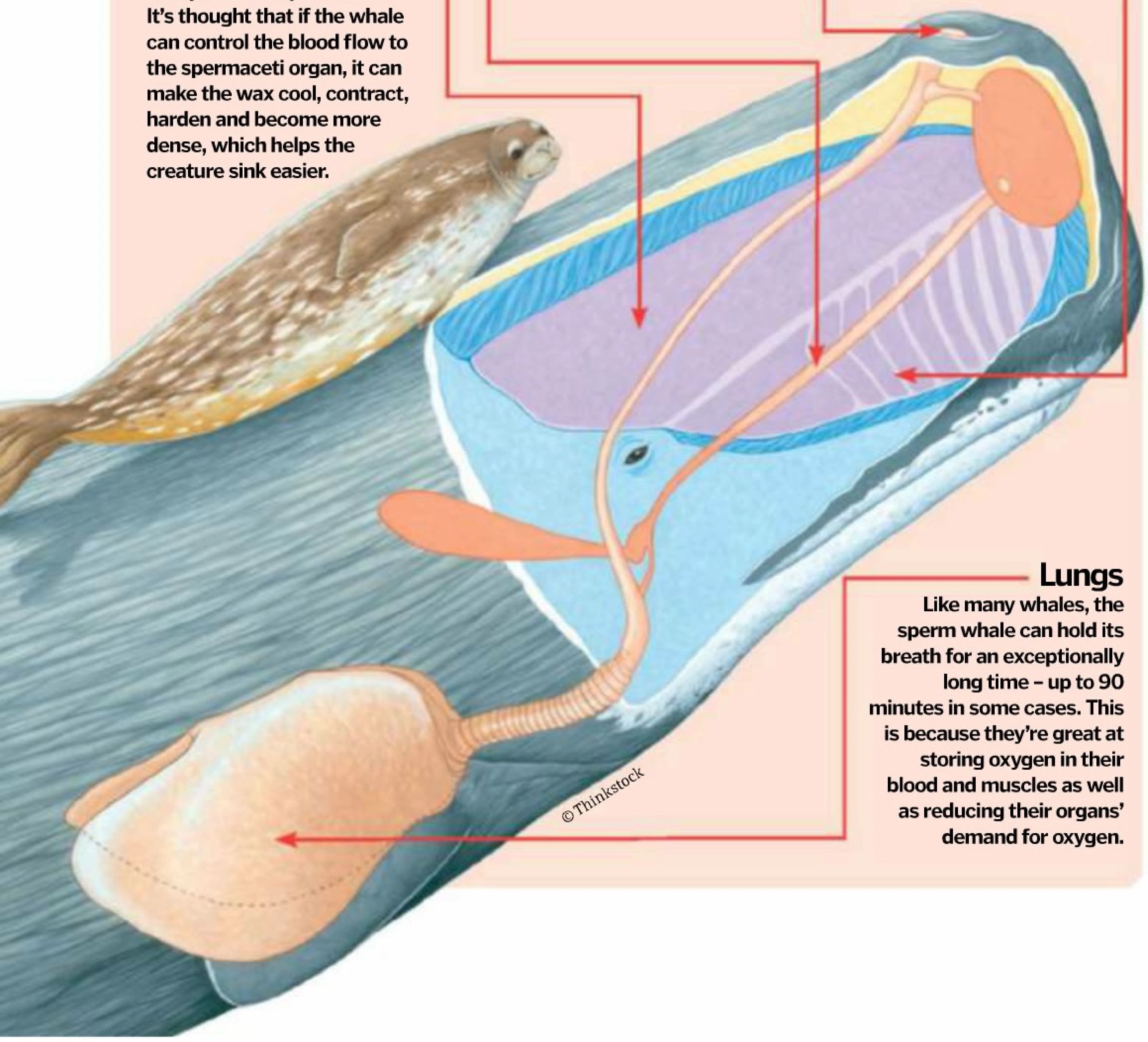
Length (female): 9-11m (30-36ft)

Weight (male): 32-41 tons

Weight (female): 14 tons

Getting inside a sperm whale's head

It has the biggest brain of any mammal, but what else is going on in this huge noggin?



Nasal passage
Water that travels across the nasal passages helps to cool the spermaceti.

Spermaceti organ
This produces spermaceti. It's thought that if the whale can control the blood flow to the spermaceti organ, it can make the wax cool, contract, harden and become more dense, which helps the creature sink easier.

Blowhole
When the whale holds its breath to dive, the blowhole seals. On surfacing, it shoots air out of its lungs forwards and left instead of straight up like other whales.

Spermaceti
This waxy substance has a melting point of around 30°C (85°F), but hardens when it gets colder, matching the density of water.

Lungs
Like many whales, the sperm whale can hold its breath for an exceptionally long time – up to 90 minutes in some cases. This is because they're great at storing oxygen in their blood and muscles as well as reducing their organs' demand for oxygen.

© Thinkstock

© SPL

Once a year beluga whales head to river estuaries to shed their dead skin

How do beluga whales moult?

What makes these white whales so well adapted to Arctic waters?

Belugas, also known as white whales, are carnivorous mammals that are found in and around the Arctic coastal regions of Europe, Asia and North America. Beluga whale skin is grey at birth (as it serves as better camouflage) and gradually becomes lighter till at around the age of five it becomes creamy white, giving them their unique appearance.

To keep them warm during the freezing Arctic winters, the belugas have extremely thick insulating skin – 100 times thicker than human skin. In the summer months, however, belugas take part in an unusual custom whereby they group together in pods and head for the shallow fresh waters of river estuaries to moult. Once in the shallows, the groups roll around on the mud and rocks to wear away the dead skin.

Unlike other whales, belugas don't have fused neck bones and so they are the only whales capable of turning their heads.

Blue whales

What's as long as three London buses and as heavy as 112 giraffes?

The blue whale isn't just the largest animal alive, it is the largest animal ever to have lived. Even the largest dinosaurs are topped by this leviathan. Everything about the blue whale is huge. It has a heart the size of a small car, a tongue that weighs 2.7 tons and lungs that can hold 5,000 litres of air.

Blue whales spend most of their lives swimming alone or in pairs, unlike other baleen whales such as the humpback. The female gives birth every two or three years to a single calf that weighs as much as an adult hippopotamus. For the first seven months, the calf drinks more than 400 litres of milk a day to enable it to put on 90kg of weight every 24 hours.

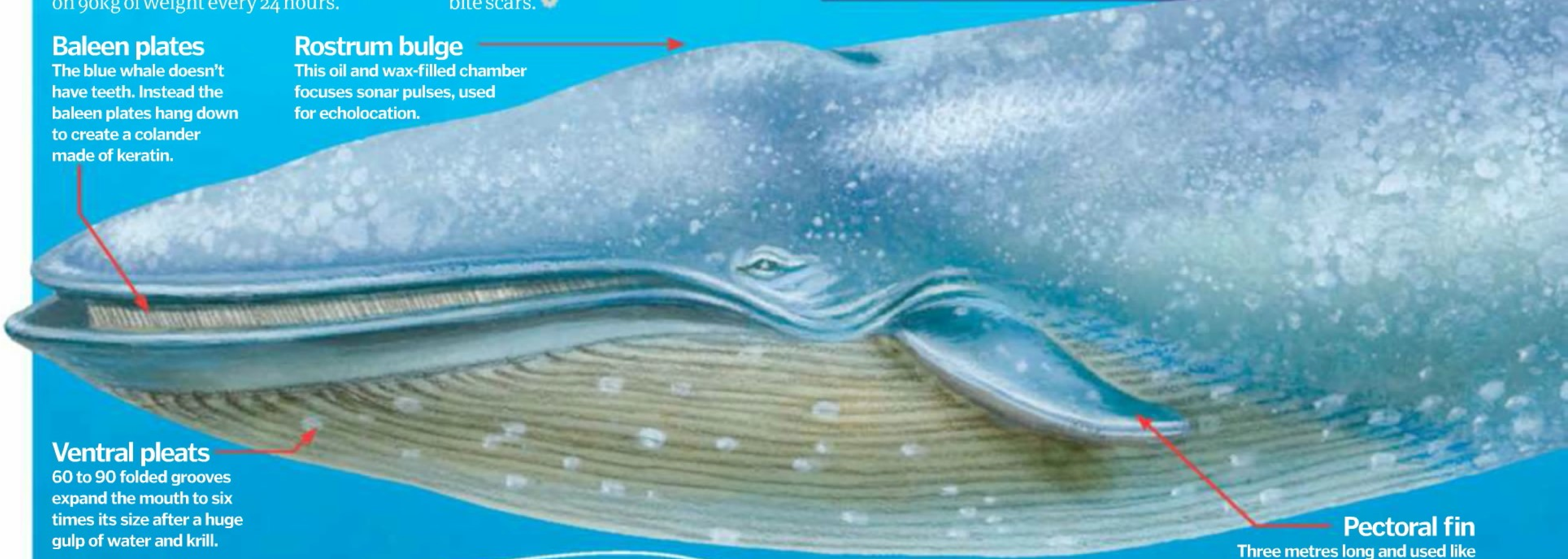
Blue whales aren't really very blue. The top half of their body is a bluish grey and the underside is a lighter colour to make them harder to see when viewed from below, against the sky.

Blue whales are also extremely fast swimmers. They cruise at 20kph and can sprint at 50kph. This makes it virtually impossible for barnacles and other parasites to attach themselves. In spring, however, a thin film of diatom algae growing on the skin can sometimes give them a yellow-orange hue and 19th Century whalers referred to them as `sulphur bottoms'.

Despite their size, blue whales are preyed upon by orcas (killer whales) and 25 per cent of adult blue whales show orca bite scars. ❁

One in four blue whales show scars caused by orcas

© Morningdew05



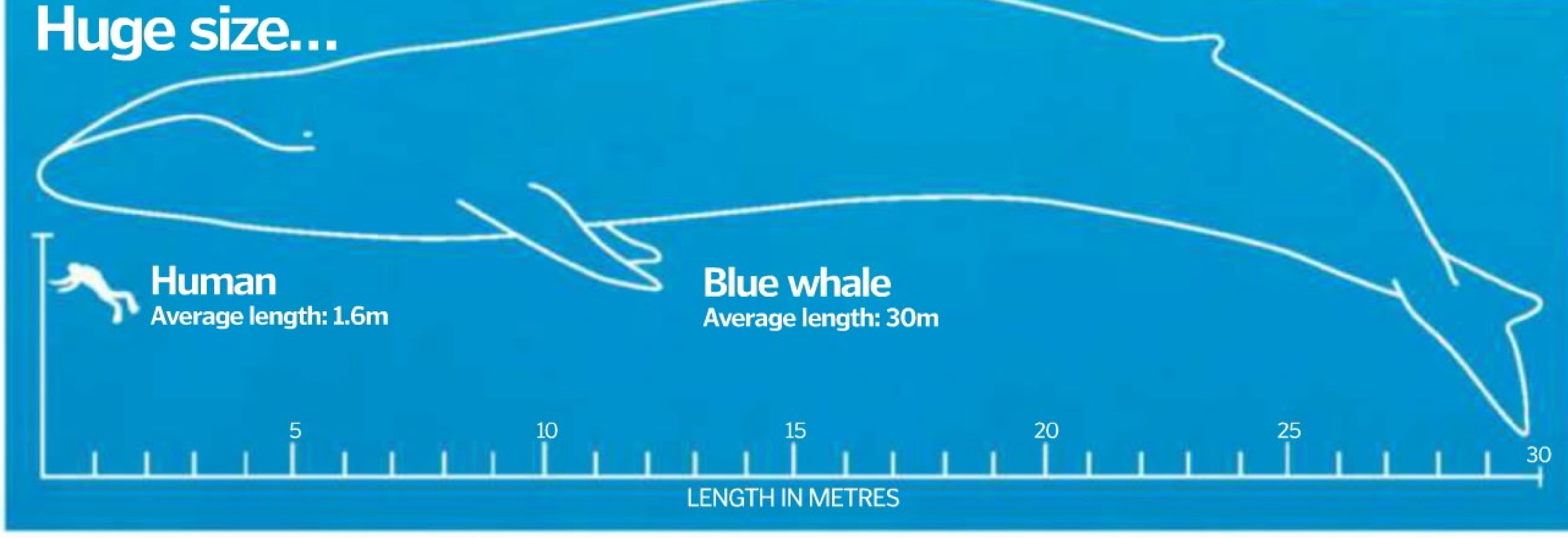
Baleen plates
The blue whale doesn't have teeth. Instead the baleen plates hang down to create a colander made of keratin.

Rostrum bulge
This oil and wax-filled chamber focuses sonar pulses, used for echolocation.

Ventral pleats
60 to 90 folded grooves expand the mouth to six times its size after a huge gulp of water and krill.

Pectoral fin
Three metres long and used like the diving planes in a submarine to adjust depth and for steering.

Huge size…



A blue whale swimming with her calf

© Andreas Tille

5 TOP FACTS LARGEST MAMMALS

African elephant
1 SIZE: 5,400kg
The largest land animal currently living. Elephants are large enough to be safe from all predators but must spend 16 hours a day eating.

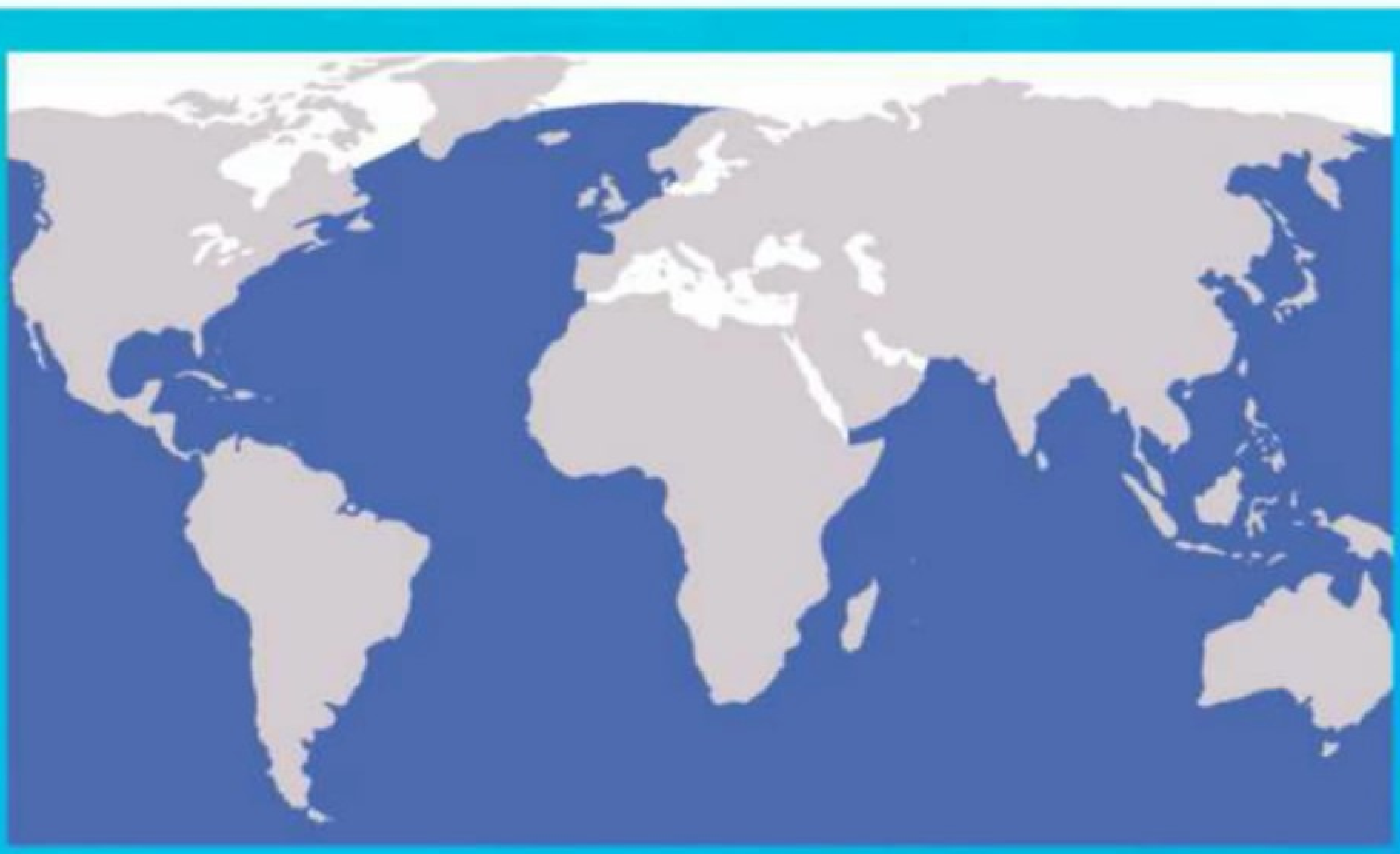
Polar bear
2 SIZE: 600kg
The largest bear and the largest land carnivore, although it spends much of its time in the sea. Its bite can crush a seal skull.

Mountain gorilla
3 SIZE: 200kg
The largest primate. Although they have powerful canine teeth, they are herbivores with a diet that includes celery, bamboo and stinging nettles.

Whale shark
4 SIZE: 36,000kg
The largest fish, whale sharks are filter feeders like the blue whale, but their food is even smaller than krill – microscopic plankton.

Blue whale
5 SIZE: 180,000kg
The largest animal that has ever lived. Its upper lip bone is the largest bone in the animal kingdom ever discovered.

DID YOU KNOW? *A blue whale's heart beats five times a minute. It pushes ten tons of blood through a million miles of vessels*



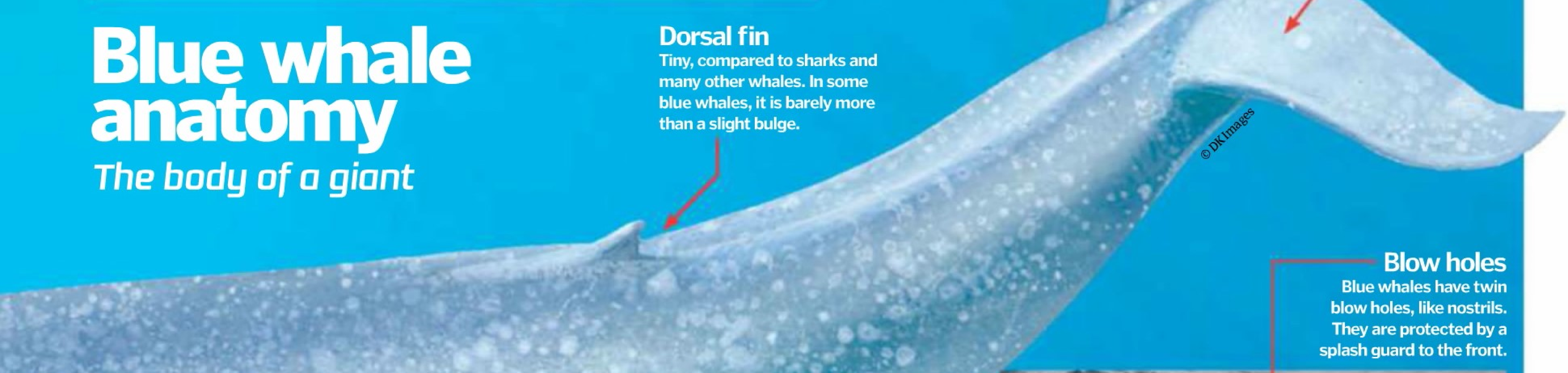
ON THE MAP

Where to find blue whales

Shown in blue, these behemoths roam virtually the whole ocean, following the seasonal abundance of the various species of krill. They avoid shallow seas such as the North Sea however, because their main defence against orca attacks is their ability to dive deeper.

Blue whale anatomy

The body of a giant

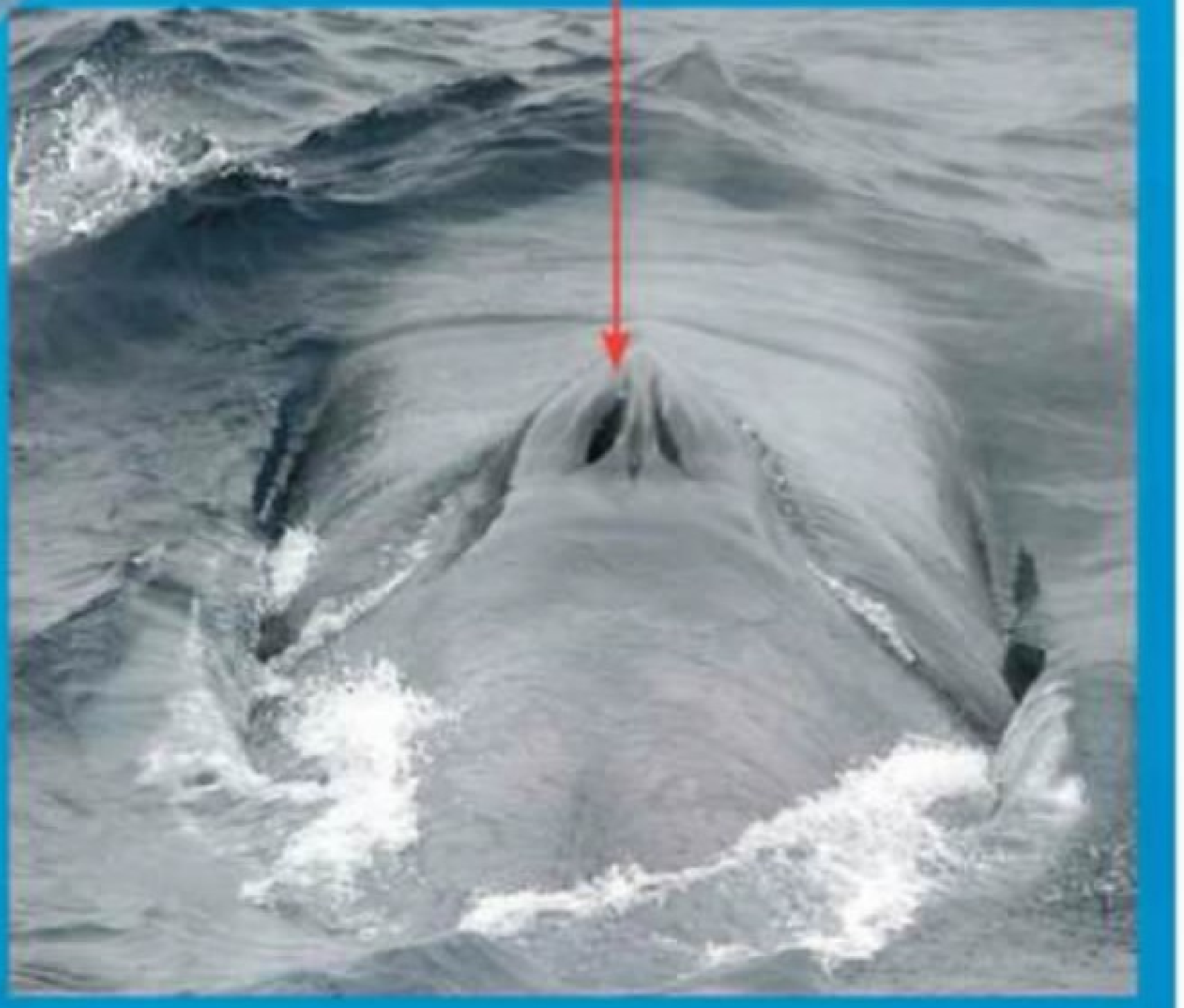


Tail flukes
Like all whales, the tail flukes are horizontal, unlike a fish's vertical tail. Capable of propelling the whale at 50kph.

Dorsal fin
Tiny, compared to sharks and many other whales. In some blue whales, it is barely more than a slight bulge.

© DK Images

Blow holes
Blue whales have twin blow holes, like nostrils. They are protected by a splash guard to the front.



Blubber
Up to half a metre thick in places. It conserves body heat and keeps a rigid shape to reduce drag.

The Statistics

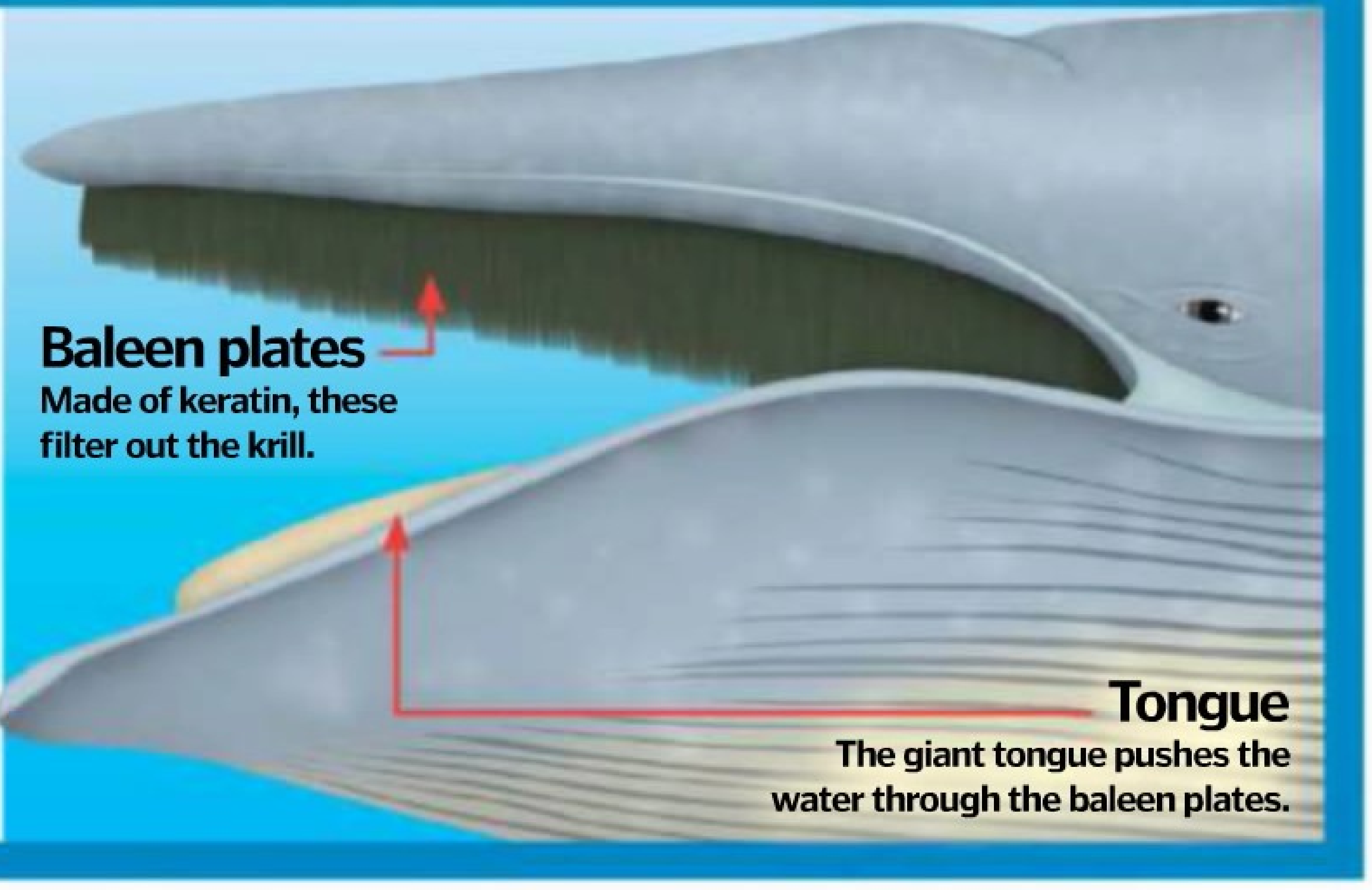
Blue whale

Type: Mammal
Diet: Carnivore
Average life span: 80 years
Weight: 180 tons
Size: 30m

How does the largest animal feed on one of the smallest?

Blue whales don't eat plankton. Instead they eat krill, which are one step up from plankton in the food chain. Krill resemble small shrimp, except that they swim in open water in huge swarms. Most krill are only a couple of centimetres long and since a blue whale needs around 1.5 million calories every day, that means it needs to eat a lot of krill – up to 40 million a day, in fact.

To catch them, a blue whale swims at speed towards a swarm and opens its mouth to gulp in 90 tons of water at a time. It then uses its massive tongue to force the water back through the baleen plates. These are 300 feathery bars, each one a metre long, that are attached to the upper jaw. They are made of keratin, like your fingernails. The krill get sieved out by the baleen and then swallowed.



Baleen plates
Made of keratin, these filter out the krill.

Tongue
The giant tongue pushes the water through the baleen plates.

How killer whales hunt

To merely call them the wolves of the sea is a gross underestimation

Killer whales aren't whales (they are more closely related to dolphins) and it's not fair to call them killers either. There are no confirmed cases of fatal attacks on humans by killer whales in the wild. But they are incredibly intelligent hunters – probably second only to humans. Killer whales, or orcas, can swim at 56 kilometres (35 miles) per hour (or 30 knots), they have teeth eight centimetres (three inches) long and their echolocation system allows them to find prey in complete darkness. But what really sets them apart is their ability to plan, improvise and work as a team.

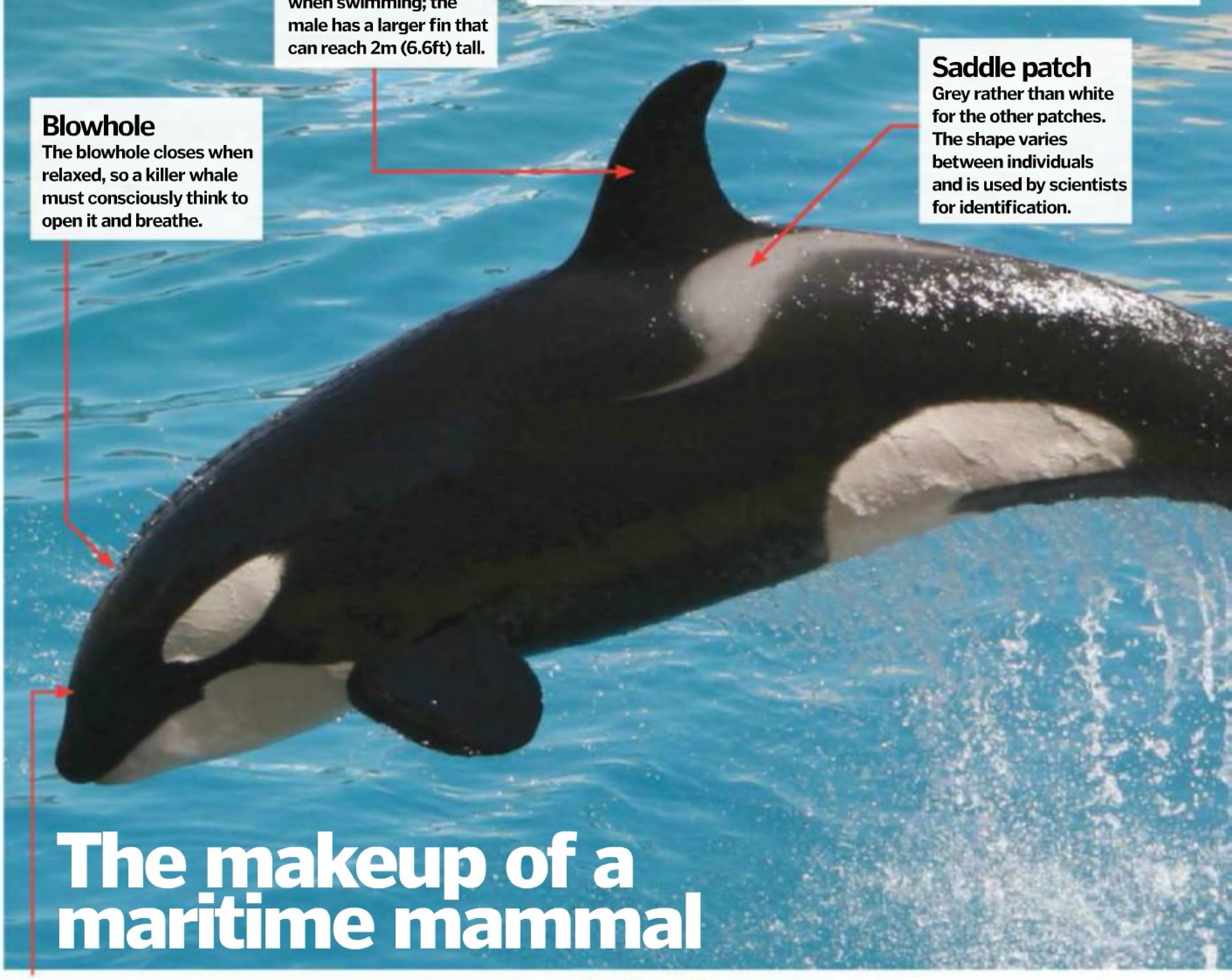
Orcas live in loose family groups called pods, of five to seven individuals. In the wild their life span can be 60 years or more but the infant mortality rate is very high; up to half will die before they are seven months old. This is mainly due to the difficulty of finding enough food. Killer whales are mammals and their warm-blood metabolism uses a lot of energy. An adult needs 230 kilograms (510 pounds) of food a day.

To feed this appetite, some subspecies prey on schools of fish by circling below them and releasing a stream of bubbles to confuse them. Others have learned that they can catch sharks by flipping them on to their backs to induce a sort of panic stun, known as tonic immobility. The killer whales that hunt among the Arctic sea ice catch seals and walruses by knocking them off ice floes into the water (see 'Hunting as a pack' boxout).

These are not purely instinctive behaviours; orcas will teach their young, often deliberately catching and releasing a seal several times to allow them to practise hunting. In 2005 scientists observed a killer whale regurgitating fish at the water's surface to lure seagulls down before catching the birds. Four other orcas subsequently learned this tactic.

© E Lazareva/FEROP

In April 2012 the first ever all-white orca – named Iceberg due to his 2m (6.6ft) dorsal fin – was spotted off the coast of eastern Russia

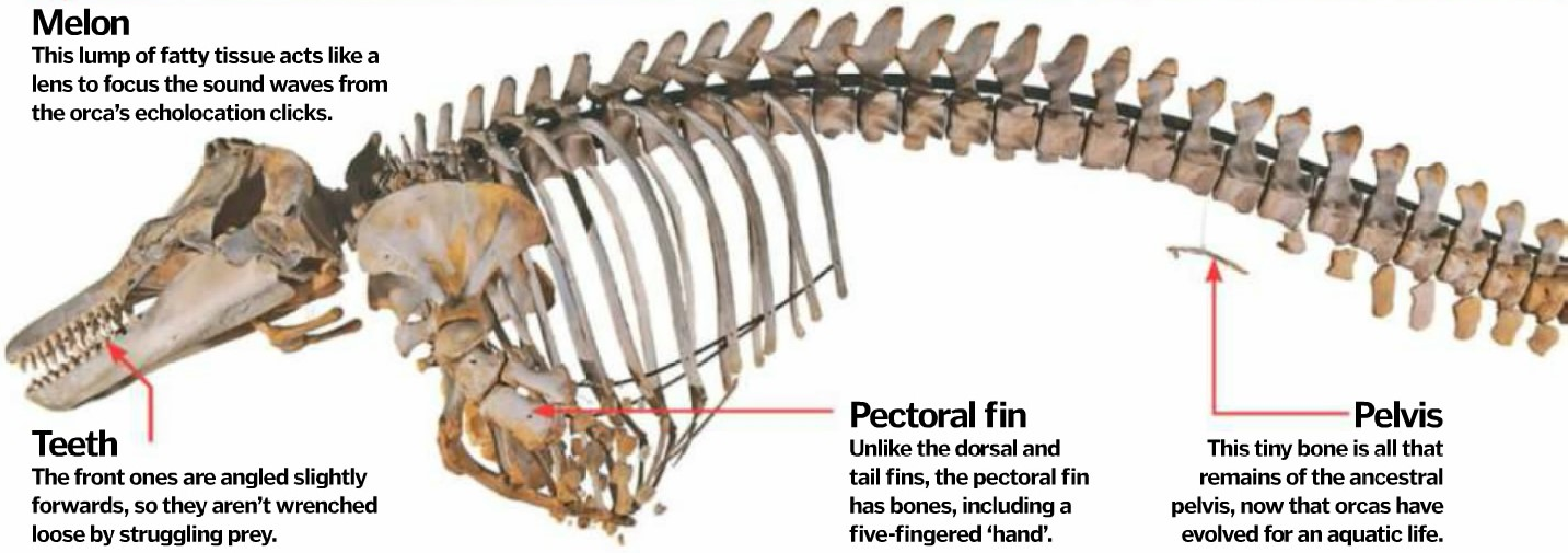


The makeup of a maritime mammal

Dorsal fin
Provides roll stability when swimming; the male has a larger fin that can reach 2m (6.6ft) tall.

Blowhole
The blowhole closes when relaxed, so a killer whale must consciously think to open it and breathe.

Saddle patch
Grey rather than white for the other patches. The shape varies between individuals and is used by scientists for identification.



Melon
This lump of fatty tissue acts like a lens to focus the sound waves from the orca's echolocation clicks.

Teeth
The front ones are angled slightly forwards, so they aren't wrenched loose by struggling prey.

Pectoral fin
Unlike the dorsal and tail fins, the pectoral fin has bones, including a five-fingered 'hand'.

Pelvis
This tiny bone is all that remains of the ancestral pelvis, now that orcas have evolved for an aquatic life.

DID YOU KNOW? *Killer whales have been found as far as 160km (100mi) inland in rivers in the USA and Canada*

The statistics...

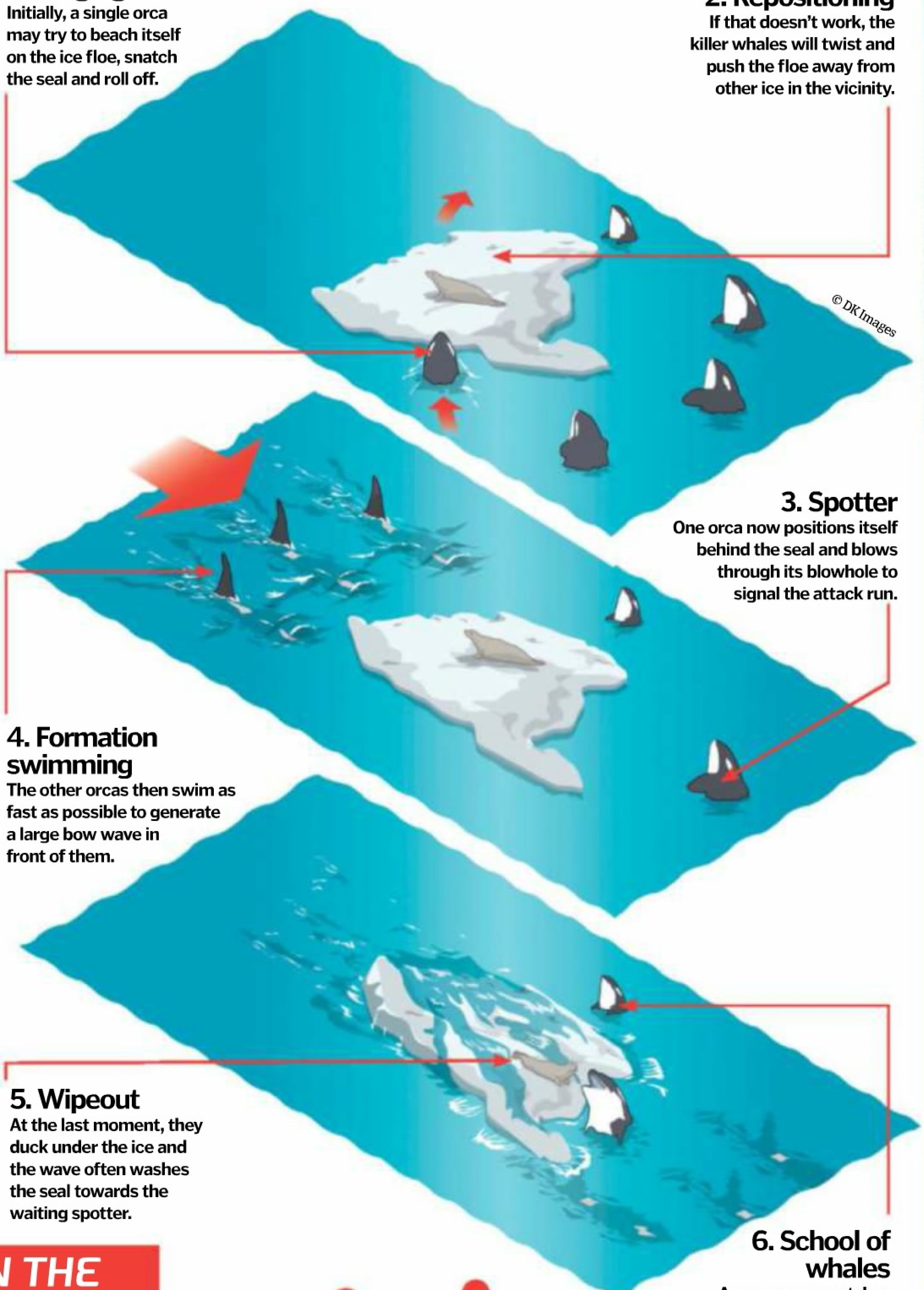
Killer whale

Genus: Orcinus
Type: Mammal
Length: 7-10m (23-32ft)
Diet: Carnivore (eg fish, seals)
Weight: 6 tons
Life span in wild: 50-80 years
Status: Threatened

Tail fluke
Most of the thrust from the tail is generated on the upstroke of the two flukes, not the downstroke.

Median notch
Helps to reduce turbulence in the orca's wake, and thereby keep drag to a minimum.

HUNTING AS A PACK



© DK Images

1. Lunging
Initially, a single orca may try to beach itself on the ice floe, snatch the seal and roll off.

2. Repositioning
If that doesn't work, the killer whales will twist and push the floe away from other ice in the vicinity.

3. Spotter
One orca now positions itself behind the seal and blows through its blowhole to signal the attack run.

4. Formation swimming
The other orcas then swim as fast as possible to generate a large bow wave in front of them.

5. Wipeout
At the last moment, they duck under the ice and the wave often washes the seal towards the waiting spotter.

6. School of whales
A young orca watches the co-ordinated attack to learn this hunting technique.

Is keeping killer whales in captivity a good idea?

There are 42 orcas currently held in captivity in aquariums and sealife parks around the world. Since 1990, almost all of these have been born in captivity. Orcas put on an impressive show because of their huge size and striking appearance. But they are also extremely intelligent and they can be trained to perform spectacular jumps and a wide range of tricks.

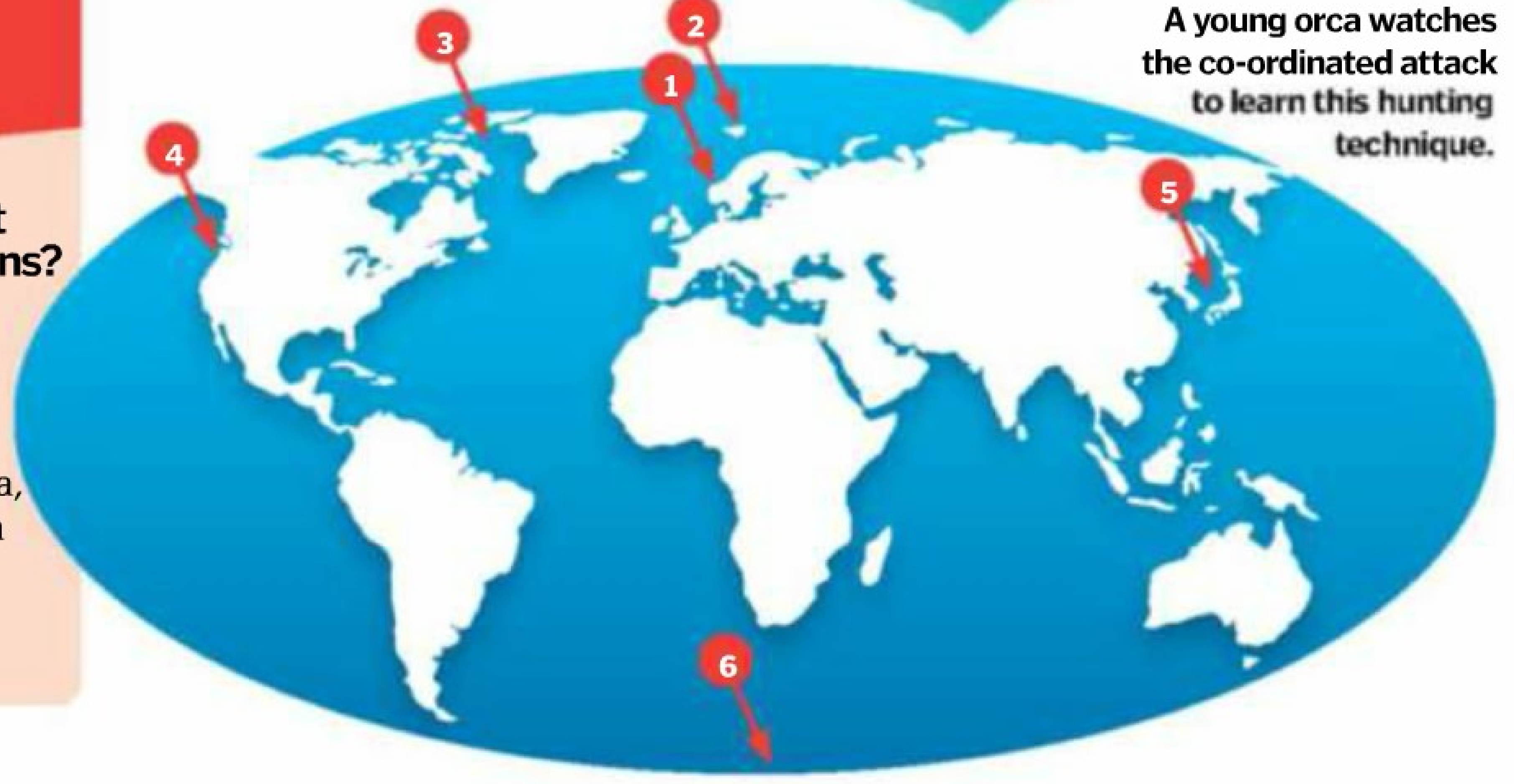
Most zoo animals have longer life spans than in the wild but the reverse is true for orcas. Lack of company from other orcas and the limited size of their tank mean they rarely live beyond 25 years. The male orca's huge dorsal fin nearly always loses rigidity and flops over after a few years in captivity. This is a permanent structural change to the fin cartilage and may be due to insufficient exercise or too much time spent swimming at the surface.

© DK Images

ON THE MAP

Where are the largest killer whale populations?

1 Norwegian coast
2 Coast of Iceland
3 Canadian Arctic and Greenland
4 Coast of British Columbia, Washington and Oregon
5 Sea of Japan
6 Southern Ocean, around Antarctica



The life of a narwhal

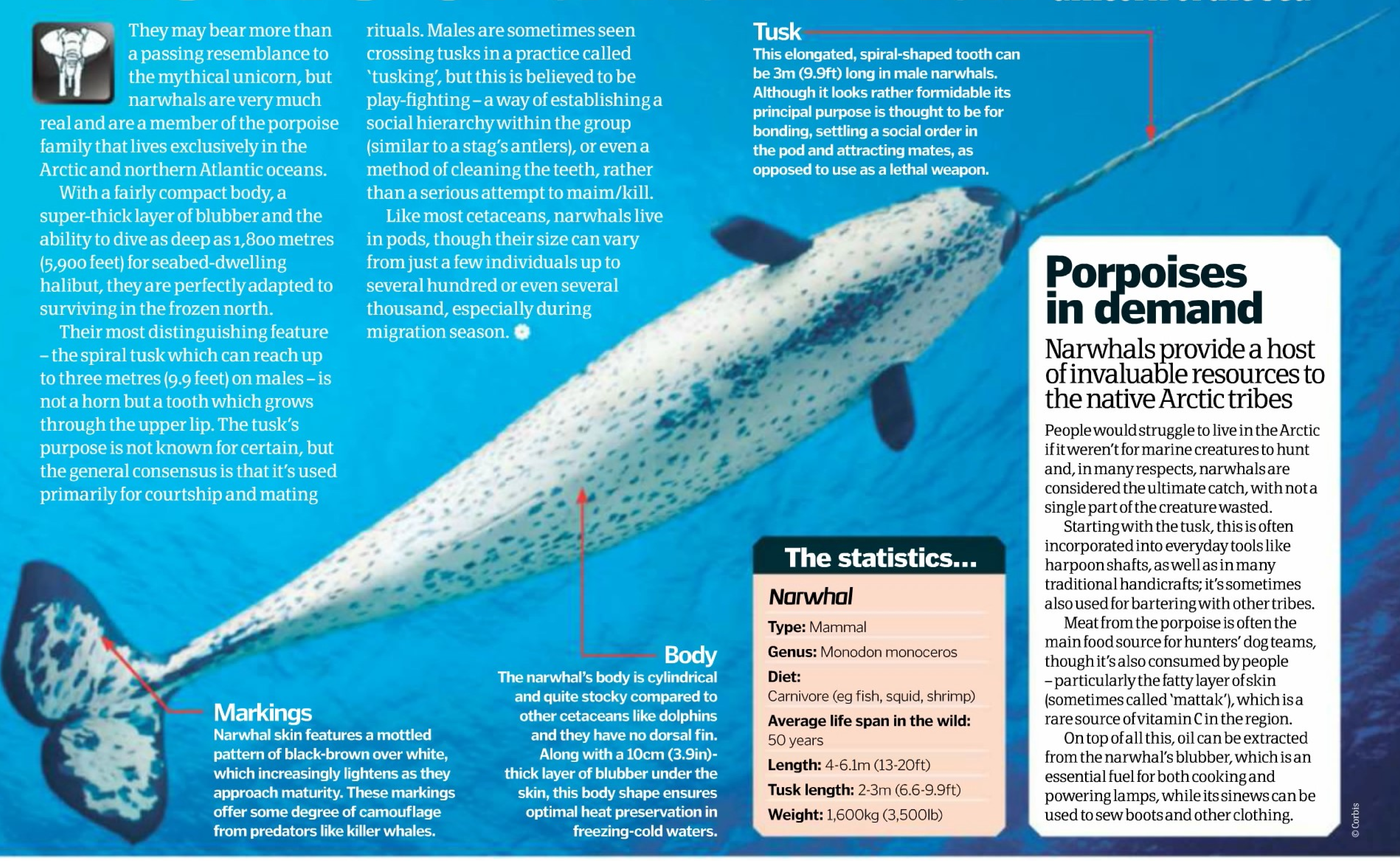
A closer look at the 'unicorn of the sea'

They may bear more than a passing resemblance to the mythical unicorn, but narwhals are very much real and are a member of the porpoise family that lives exclusively in the Arctic and northern Atlantic oceans.

With a fairly compact body, a super-thick layer of blubber and the ability to dive as deep as 1,800 metres (5,900 feet) for seabed-dwelling halibut, they are perfectly adapted to surviving in the frozen north.

Their most distinguishing feature – the spiral tusk which can reach up to three metres (9.9 feet) on males – is not a horn but a tooth which grows through the upper lip. The tusk's purpose is not known for certain, but the general consensus is that it's used primarily for courtship and mating rituals. Males are sometimes seen crossing tusks in a practice called 'tusking', but this is believed to be play-fighting – a way of establishing a social hierarchy within the group (similar to a stag's antlers), or even a method of cleaning the teeth, rather than a serious attempt to maim/kill.

Like most cetaceans, narwhals live in pods, though their size can vary from just a few individuals up to several hundred or even several thousand, especially during migration season.



Tusk
This elongated, spiral-shaped tooth can be 3m (9.9ft) long in male narwhals. Although it looks rather formidable its principal purpose is thought to be for bonding, settling a social order in the pod and attracting mates, as opposed to use as a lethal weapon.

Body
The narwhal's body is cylindrical and quite stocky compared to other cetaceans like dolphins and they have no dorsal fin. Along with a 10cm (3.9in)-thick layer of blubber under the skin, this body shape ensures optimal heat preservation in freezing-cold waters.

Markings
Narwhal skin features a mottled pattern of black-brown over white, which increasingly lightens as they approach maturity. These markings offer some degree of camouflage from predators like killer whales.

The statistics...

Narwhal

Type: Mammal

Genus: Monodon monoceros

Diet: Carnivore (eg fish, squid, shrimp)

Average life span in the wild: 50 years

Length: 4-6.1m (13-20ft)

Tusk length: 2-3m (6.6-9.9ft)

Weight: 1,600kg (3,500lb)

Porpoises in demand

Narwhals provide a host of invaluable resources to the native Arctic tribes

People would struggle to live in the Arctic if it weren't for marine creatures to hunt and, in many respects, narwhals are considered the ultimate catch, with not a single part of the creature wasted.

Starting with the tusk, this is often incorporated into everyday tools like harpoon shafts, as well as in many traditional handicrafts; it's sometimes also used for bartering with other tribes.

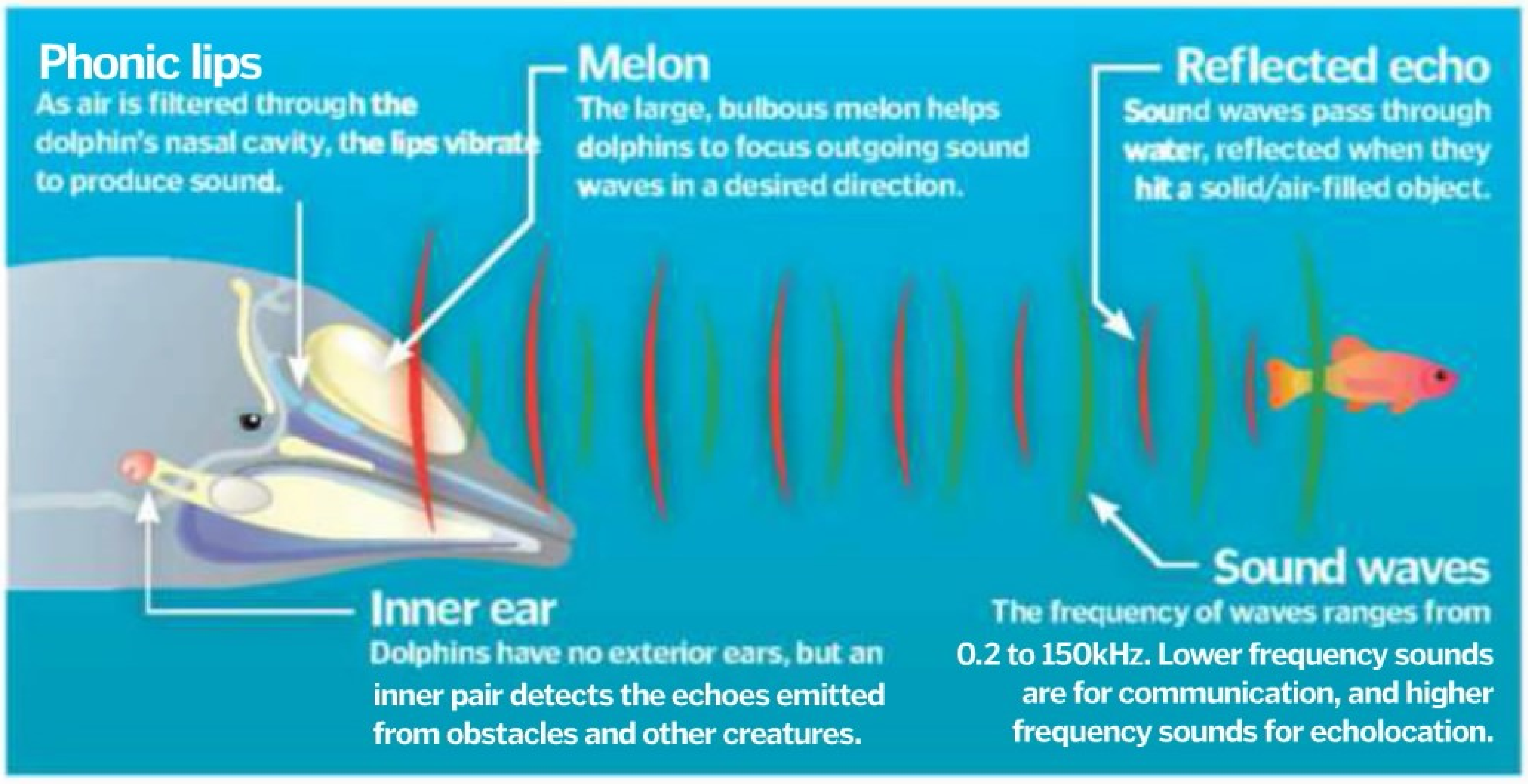
Meat from the porpoise is often the main food source for hunters' dog teams, though it's also consumed by people – particularly the fatty layer of skin (sometimes called 'mattak'), which is a rare source of vitamin C in the region.

On top of all this, oil can be extracted from the narwhal's blubber, which is an essential fuel for both cooking and powering lamps, while its sinews can be used to sew boots and other clothing.

© Corbis

Dolphin noises

With no vocal cords, how and why do these intelligent mammals communicate?



Phonic lips
As air is filtered through the dolphin's nasal cavity, the lips vibrate to produce sound.

Melon
The large, bulbous melon helps dolphins to focus outgoing sound waves in a desired direction.

Reflected echo
Sound waves pass through water, reflected when they hit a solid/air-filled object.

Inner ear
Dolphins have no exterior ears, but an inner pair detects the echoes emitted from obstacles and other creatures.

Sound waves
The frequency of waves ranges from 0.2 to 150kHz. Lower frequency sounds are for communication, and higher frequency sounds for echolocation.

Dolphins produce sound from 'phonic lips', located in their nasal cavity. These muscular tissues, when stimulated by passing air, allow them to form a variety of sounds of varying frequencies, such as clicks, whistles and moans. This is similar to how humans produce sounds by exhaling air from their lungs through the larynx, but differs as dolphins do not shape and project these sounds through their mouth, relying instead on a large fatty structure known as the 'melon' to amplify and focus them.

Dolphins communicate by producing low-frequency noises (0.2 to 50kHz) which travel at 0.9 miles per second (1.4kps), roughly 4.5 times faster than through air. These lower frequencies travel further than higher ones and, along with a signature whistle formed in infancy, enable communication over large distances.

Echolocation allows dolphins to locate and discriminate objects, animals and terrain via a sequence of high-frequency sound waves (the characteristic clicking sounds). Clicks range in frequencies from 40-130kHz and usually last between 50 to 128 microseconds. Echolocation sound waves are amplified and directed by the melon and their echoes (when the waves hit an object and bounce back) are received by an inner ear, then sent to the brain in the form of nerve impulses. As dolphins have two phonic lip complexes, they can communicate and echolocate at the same time.

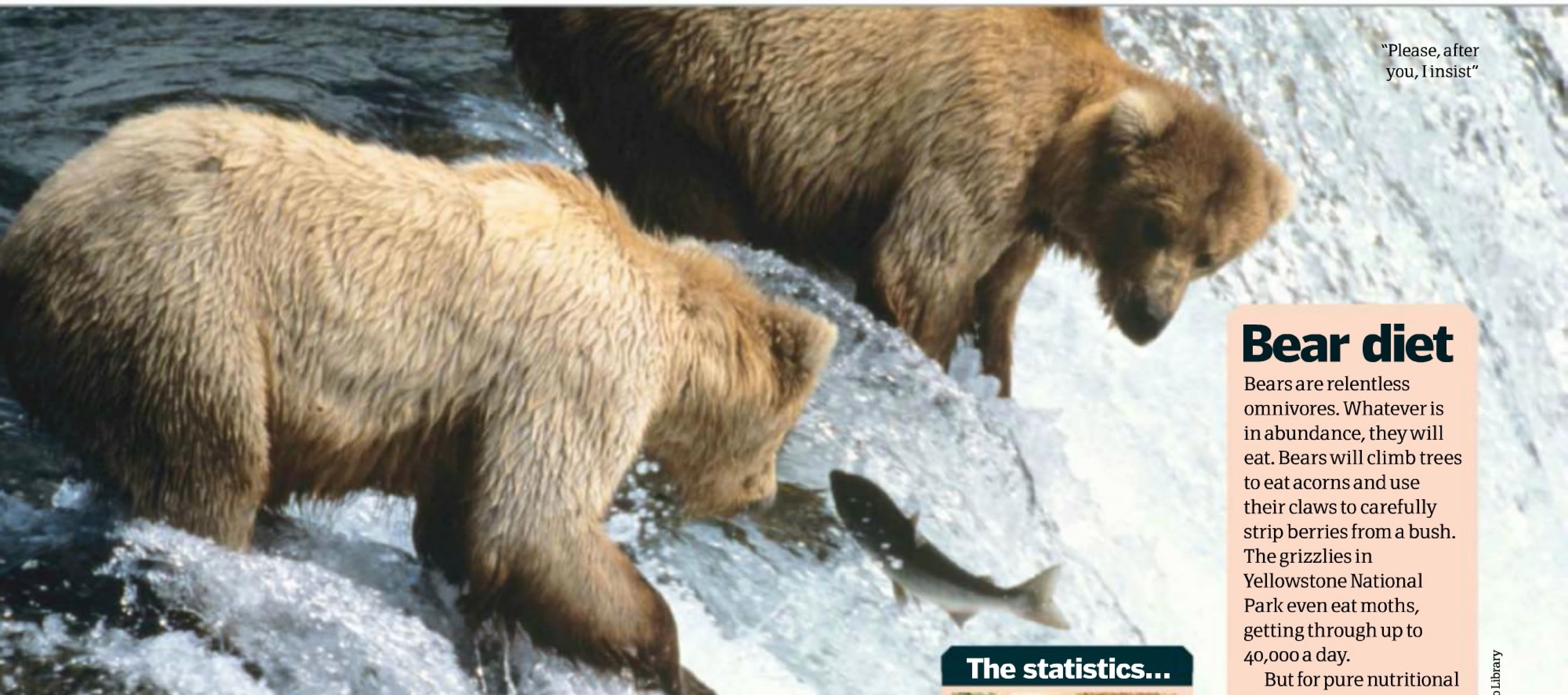
DID YOU KNOW?

© Malene Tyssen

The ones that get away

At the height of the salmon run, a bear can catch one fish every 20 minutes and will eat 40kg of salmon every day. Despite this, more than 200 fish will get past, for every one the bear catches.

DID YOU KNOW? *Bears don't like to get their ears wet and use their hind legs to kick fish out of deep pools, rather than dive in*


"Please, after you, I insist"

© Science Photo Library

How do bears catch fish?

Need to catch a 30-pound salmon without a rod or net? Just grin and bear it

In July and August each year, tens of thousands of fat salmon migrate back up the rivers of Northern America and Eastern Russia to spawn. For an opportunistic hunter like the brown bear, this is too good to miss.

A bear perched at the top of a low waterfall catching fish in mid air makes for a great photograph, but the right sort of waterfall is relatively rare and competition from other hungry bears at these spots can be very fierce. It also requires perfect reflexes. The bear has just one chance to snatch the slippery, struggling fish with a grip firm enough to make it back to the shore without it wriggling free. If he drops it, the fast-flowing water will whisk away his prize, even if the fish is already dead.

A much better hunting ground is where the river becomes broad and shallow. In ankle-deep water, the bear can outrun the salmon as they frantically flap themselves over the stones, and pinning one to the riverbed with heavy claws is much easier. Bears also watch from the bank as salmon rest in calmer pools close to shore. They will then suddenly leap and try to snatch a fish in their jaws.

The bear's fearsome claws may be deadly weapons on land, but against salmon they aren't much use. Bears don't have opposable thumbs so they can't grip the fish and brown bear claws are quite blunt. But they have very powerful jaws with huge, backward-curving canine teeth. Bears will attempt to snag the fish with the front of the mouth when they strike, but they will often then hold the fish against the crook of their elbow. This lets them get a better grip on the salmon with the molars at the back of the mouth, so they can securely carry it to the shore.

The statistics...

Brown bear

Class: Mammal

Family: Ursidae

Diet: Omnivore

Average life span in the wild: 25 years

Weight: 300-550kg

Size: 1.5-2.7m long

Bear diet

Bears are relentless omnivores. Whatever is in abundance, they will eat. Bears will climb trees to eat acorns and use their claws to carefully strip berries from a bush. The grizzlies in Yellowstone National Park even eat moths, getting through up to 40,000 a day.

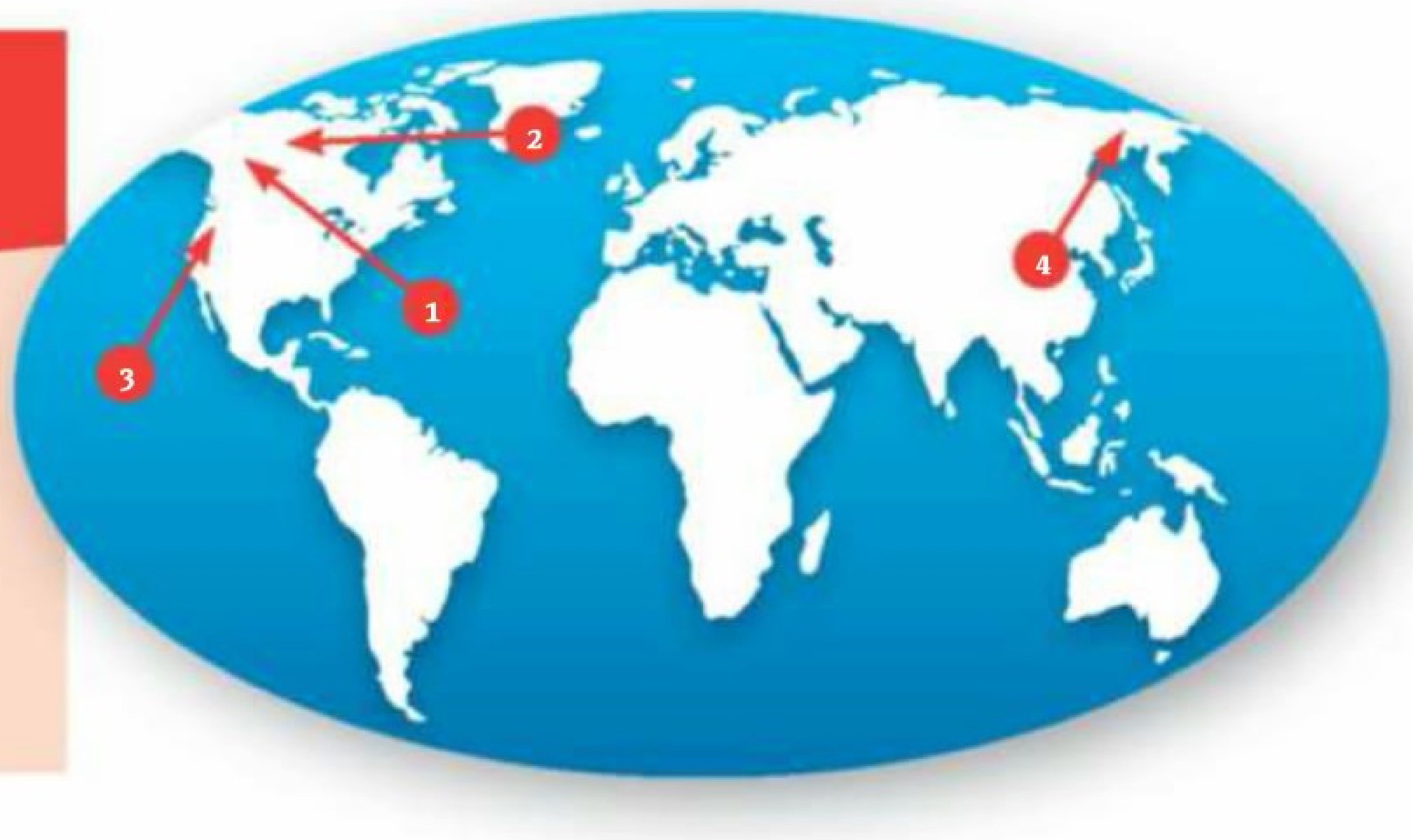
But for pure nutritional value, almost nothing beats salmon. Spawning salmon are full of eggs and their skin is rich in fat. Bears get ten times as much energy from fish as they do from berries. Through summer and early-autumn they will eat 20,000 calories a day – as much as ten adult humans – to put on enough weight to last through the winter.

Dare you to take it off him...

ON THE MAP

Where do fish-eating bears live?

1 Katmai National Park, Alaska
2 British Columbia, Canada
3 Lake Tahoe, Northern California
4 Kamchatka, Siberia



Kings of the Arctic

How polar bears hunt and survive

The polar bear may seem cute and cuddly, but these mammoth mammals of the Arctic are a hardened species, set out to survive in these subzero temperatures, plunging to as much as -45° Celsius.

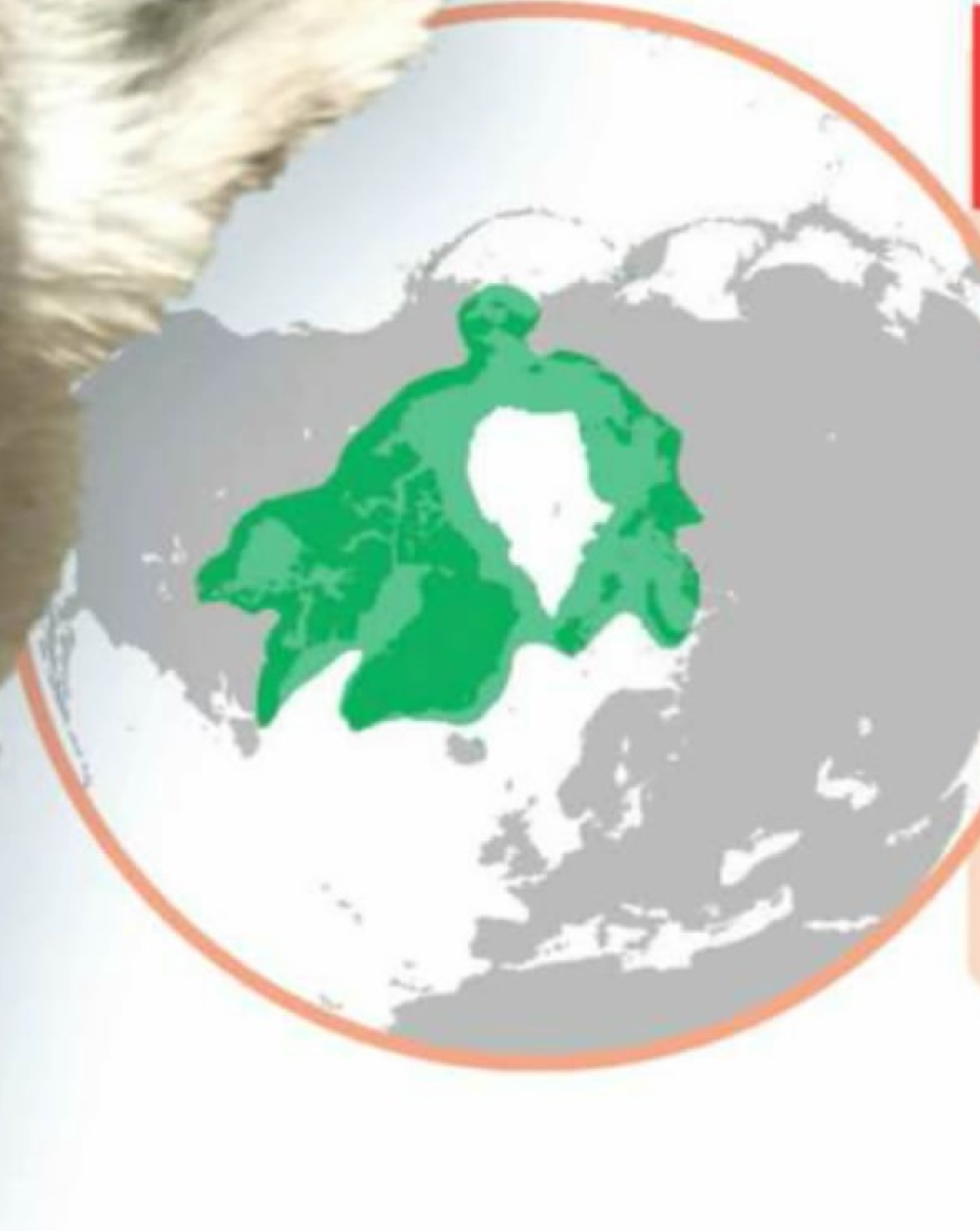
The polar bear, or Ursus maritimus – which means sea bear – have been recorded to weigh as much as 2,209 pounds, and can grow to as big as ten feet tall, when standing on their hind legs. That's a massive body mass, which includes a thick layer of blubber nearly 4.5 inches thick. Wrap this up with two additional layers of fur, which covers all of the bear's anatomy except their nose and foot pads, and Ursus maritimus stays as snug as a bug. Pure white to creamy yellow/light brown in colouration, depending upon season and angle of light, makes for a perfect combination for surprising prey.

Other essential parts of the anatomy, such as the paws and snout, help them thrive in these harsh conditions. Polar bears' paws are large compared to its body size. Measuring 12 inches, they include thick, curved, non-retractable claws, essential for catching large prey, as well as for traction when

A family of polar bears receive a surprise visit from a Russian sub

Polar bears are animals without boundaries, padding across the ice from Russia to Alaska, from Canada to Greenland and onto Norway's Svalbard archipelago

© Ansgar Walk 1996



ON THE MAP

Where can you find the king of the arctic?

Found throughout the Arctic circle, polar bears can be found in five countries: Denmark (Greenland), USA (Alaska), Canada, Norway (Svalbard) and Russia. Estimates suggest that only 20,000-25,000 polar bears remain throughout the world.

Head to Head
Big, bad bears

LARGEST BEAR

1. Brown bear
The largest member of the bear family, brown bears can weigh up to 1,500 pounds. They live across northern Eurasia and the USA.

MEANEST BEAR

2. Polar bear
Rival in all but size to the brown bear, and much more deadly, polar bears are claimed to have actively hunted humans on the ice.

NOT A BEAR

3. Koala bear
Contrary to its misleading name, coastal Australia's cuddly Koala is not a bear at all but in fact a marsupial, which is an infraclass of mammals.

DID YOU KNOW? *Polar bears enjoy a relatively extended life span, most dying at a ripe age of 25 years old*

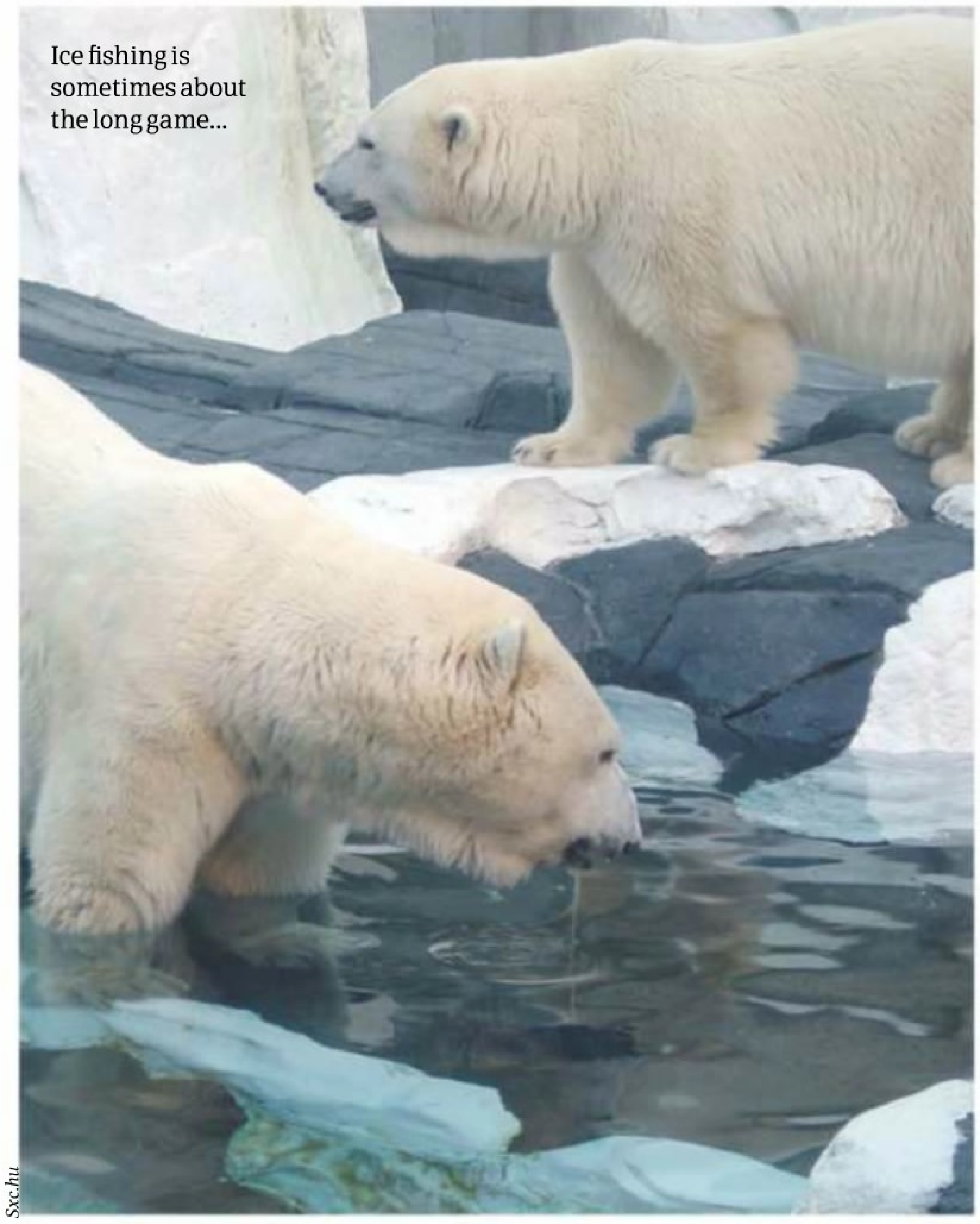
running on ice.

Small bumps, known as papillae, are also present and these help them keep their grip when manoeuvring slippery ice. Up to half the length of the bear's toes is covered with a swimming membrane, which enables them to swim at a rate of six miles per hour, and they're known to be competent swimmers as far as 320km from shore.

The bear's sense of smell is extremely acute, and becomes the most important sensory for detecting land prey. Able to smell a seal from over one kilometre away, under three feet of snow, this is extremely important to this species' survival, as snowy weather conditions impair its eyesight, which is no better than that of a normal human being. These factors firmly put Ursus maritimus at the top of the Arctic food chain.

Unfortunately, despite their great prowess, the polar bear population is dropping quickly, mainly due to the damaging effects of global warming. As the Earth heats up, larger quantities of ice are melting earlier in the year, removing the vital hunting platforms which polar bears use to hunt seals. This habitat loss is preventing polar bears from building up the requisite fat reserves to survive in the harsher and leaner parts of the year, with many succumbing to malnutrition. In addition, the loss of ice is forcing the bears to swim further and further between landmasses, draining energy that is vital for healthy reproduction, body conditioning and general survival.

> "Polar bears can smell a seal from over one kilometre away, under three feet of snow"



Ice fishing is sometimes about the long game…

Sxc.hu

A sperm whale provides a nutritious and hearty meal

Every family has its fall-outs…

5 TOP FACTS
POLAR BEARS

1 Diving depths
The polar bear makes shallow dives to catch prey, but can stay submerged for up to two minutes, in depths of up to 15 feet.

2 Female of the species
A female polar bear can bare offspring as young as four or five years old. Cub litters are most commonly twins.

3 Boys are bigger
The male is the larger of the two sexes, growing up to ten feet tall and weighing in at over 1,400 pounds. The female is a little more slender, at seven feet tall and only 650 pounds.

4 Translucent fur
Ever wondered why a polar bear looks white? Well, each hair is a transparent and pigment-free hollow tube, reflecting the light around it. Perfect camouflage for hunting prey.

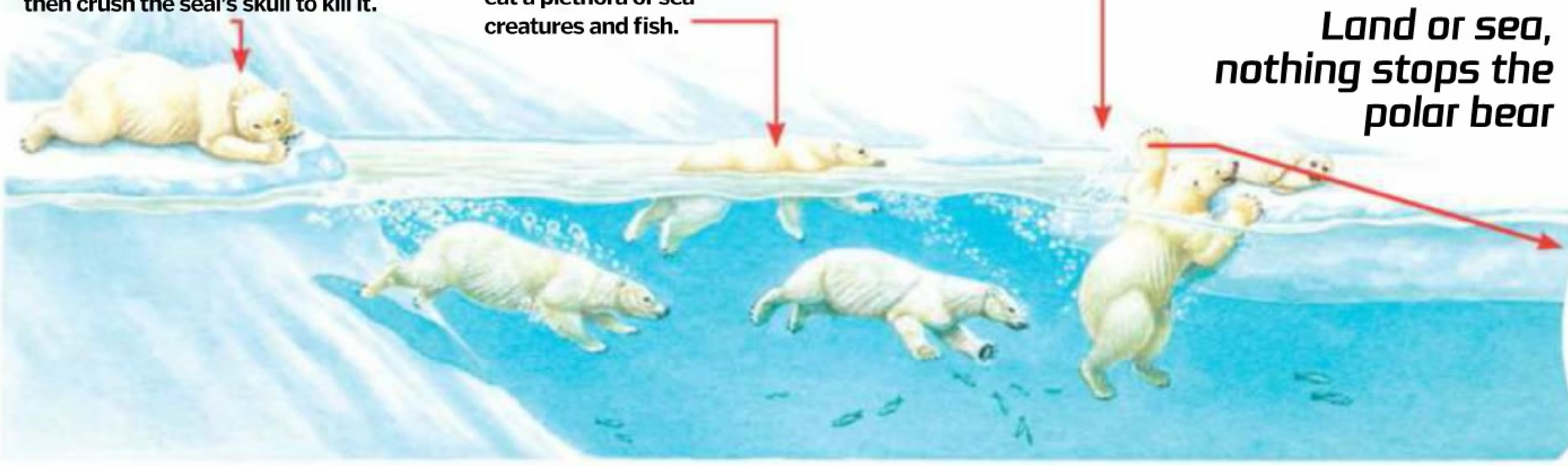
5 Bear on standby
The polar bear can slow down its own metabolism, which enables it to conserve energy at any time of the year.

On the hunt
Land or sea, nothing stops the polar bear

Locating prey
To catch prey, polar bears wait in silence outside seal breathing holes in the ice, before dragging them out when they surface to breathe. They then crush the seal's skull to kill it.

Big diet
Polar bears' diet consists mainly of land-caught seals and their pups. During the summer months they also eat a plethora of sea creatures and fish.

Devouring prey
Polar bears tend to be selective in what parts of their prey they consume, focusing on the calorie-rich skin and blubber.



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Learn more

For more information about polar bears head over to **polarbearsinternational.org/** where you can learn more about these incredibly cute but ultimately deadly beasts, and even adopt your very own cub!

> "Primates live longer than other mammals of the same size"

XXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Primates

There's more to primates than just monkeys. This diverse group also contains some of the strangest and most specialised animals in the world. We go looking for the King of the Swingers

Primates are mammals with grasping hands and feet, good vision and large brains for their body size. They evolved from squirrel-like tree-dwelling animals around 65 million years ago, just before the dinosaurs became extinct. Primates are divided into the lemurs (who only live in Madagascar), lorises, tarsiers and simians. Somewhere between 33 and 70 million years ago, a few simians made the journey from Africa to South America, probably floating on impromptu rafts of vegetation. From there, they evolved into the New World Monkeys, and they are the only primates native to that continent. The simians left behind became the Old World Monkeys – who have tails – and the apes – who don't.

There are approximately 424 species of primate currently known, mostly living in the midst of tropical rainforests. Primates are very successful mammals. Even ignoring the fact that the dominant species on Earth (homo sapiens) is a primate, this group of animals has still spread out widely across the tropical regions of the world; from the humid forests of Central America to the arid African savannah, and from the swamps of the Congo basin to the Ethiopian highlands, which are a massive 5,000m above sea level.

Primates account for as much as 40 per cent of the fruit-eating animals (by weight) in tropical rainforests and their preferences have had a major impact on the evolution of plants there. Bananas and oranges, for example, use monkeys to spread their seeds and so they have evolved skins that are very hard to peel unless you have opposable thumbs.

Primates live longer than other mammals of the same size, partly because they are often able to co-operate to defend themselves against predators. They also reproduce more slowly though, with infants hugely dependent on their parents for much longer than most other animals. Their reasonably large brains require time to fully develop, and to fill with knowledge about their environment and its numerous dangers.

Although most primates eat fruit as part of their diet, many of them have specialised for other foods as well. Lemurs eat leaves, marmosets strip tree bark to eat the gum underneath and the aye-aye has an elongated middle finger to winkle insects out of trees, like a woodpecker.

5 TOP FACTS PRIMATE FEATURES

Mouse lemur

1 Madame Berthe's mouse lemur weighs just 30 grams (1.1 ounces) and has a body that measures 9.2cm long (3.6 inches). It lives only in a small part of Madagascar.

Mountain gorilla

2 At the other end of the scale, the mountain gorilla weighs 200kg (440lb). Despite its ferocious bulk, it is completely herbivorous and mostly eats leaves.

Male proboscis monkey

3 The male proboscis monkey has a nose the size, shape and colour of a large sweet potato. Amazingly, it seems that this feature actually attracts females.

Gelada

4 The gelada is a grass eater. It has the most opposable thumb of any primate apart from humans, used to pick apart grass stalks to reach the most nutritious parts.

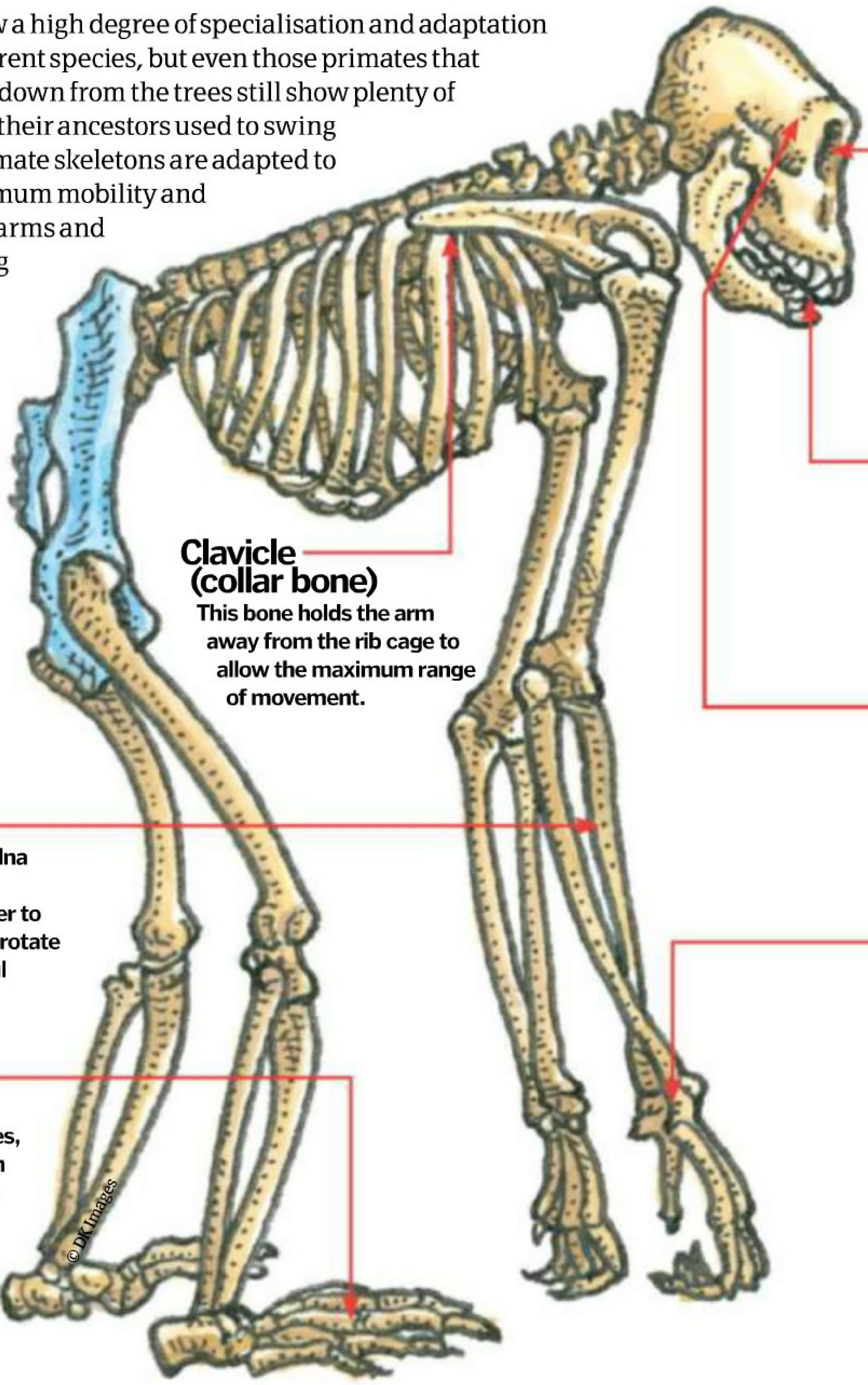
Howler monkey

5 The howler monkey is the loudest land animal. Using the enlarged hyoid bone in its neck, it makes a hooting noise that can be heard three miles away.

DID YOU KNOW? [illegible]

The skeleton of a swinger

Primates show a high degree of specialisation and adaptation between different species, but even those primates that have climbed down from the trees still show plenty of evidence that their ancestors used to swing overhead. Primate skeletons are adapted to provide maximum mobility and reach in their arms and forward-facing eyes to give depth of perception.


© DK Images

Eye sockets
Tarsiers have eyes so large, they can't move in their sockets. They rotate the whole head through up to 180° instead.

Teeth
Specialised according to diet. Leaf eaters have grinding molars, meat eaters have sharp canines.

Clavicle (collar bone)
This bone holds the arm away from the rib cage to allow the maximum range of movement.

Eyebrow ridge
This bony ridge reinforces weaker bones in the face to allow greater chewing force without damaging the skull.

Forearm
The radius and ulna bones can twist around each other to allow the arm to rotate on its axis. Useful when swinging.

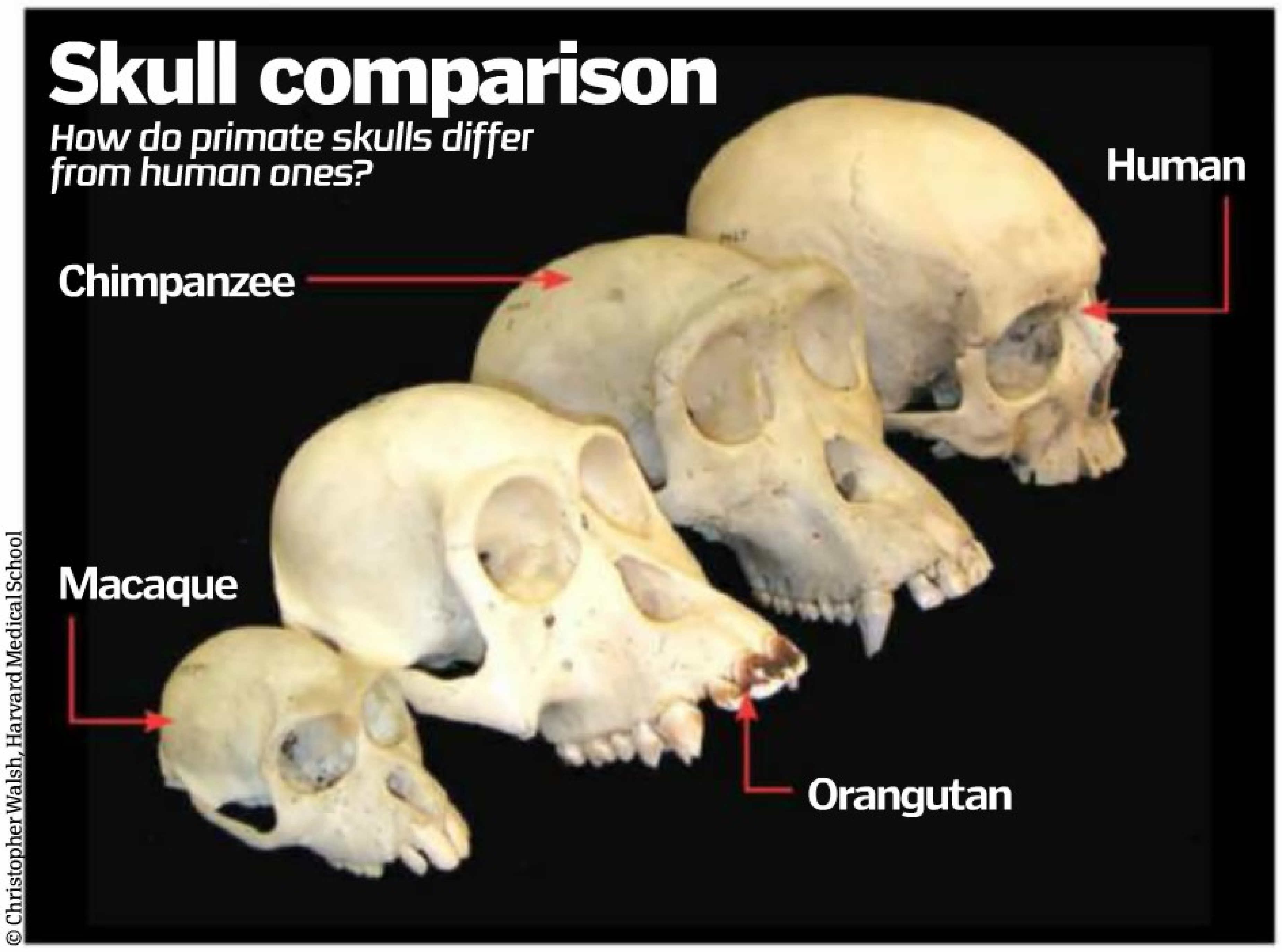
Wrist
Most primates have hinge joints at the wrist, but gibbons have a ball and socket joint, like an extra shoulder.

Fingers and toes
Elongated for gripping branches, primates walk on the palms of the hands and feet.

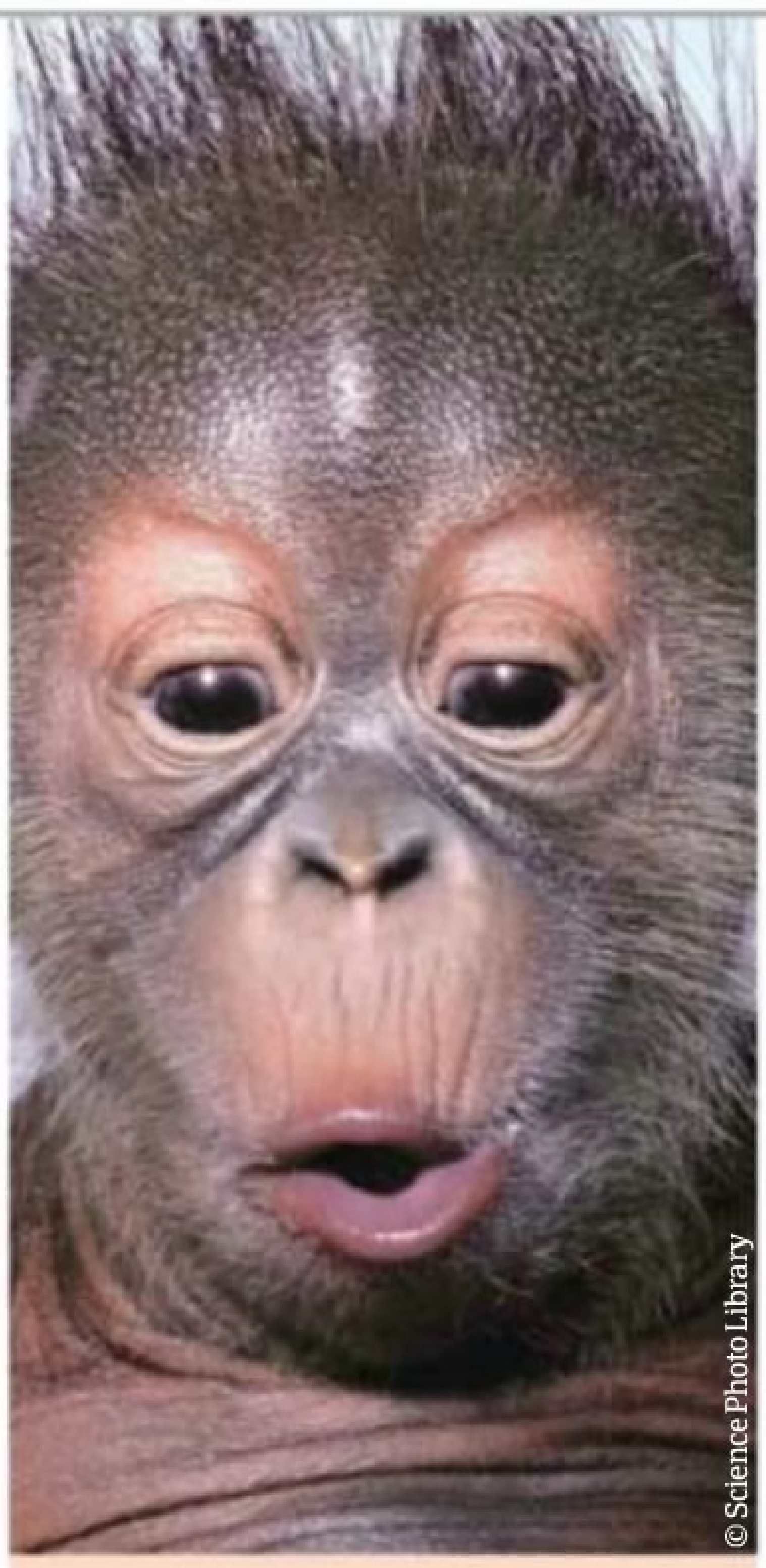
Primates, our closest relatives… see the resemblance?

Skull comparison

How do primate skulls differ from human ones?



© Christopher Walsh, Harvard Medical School



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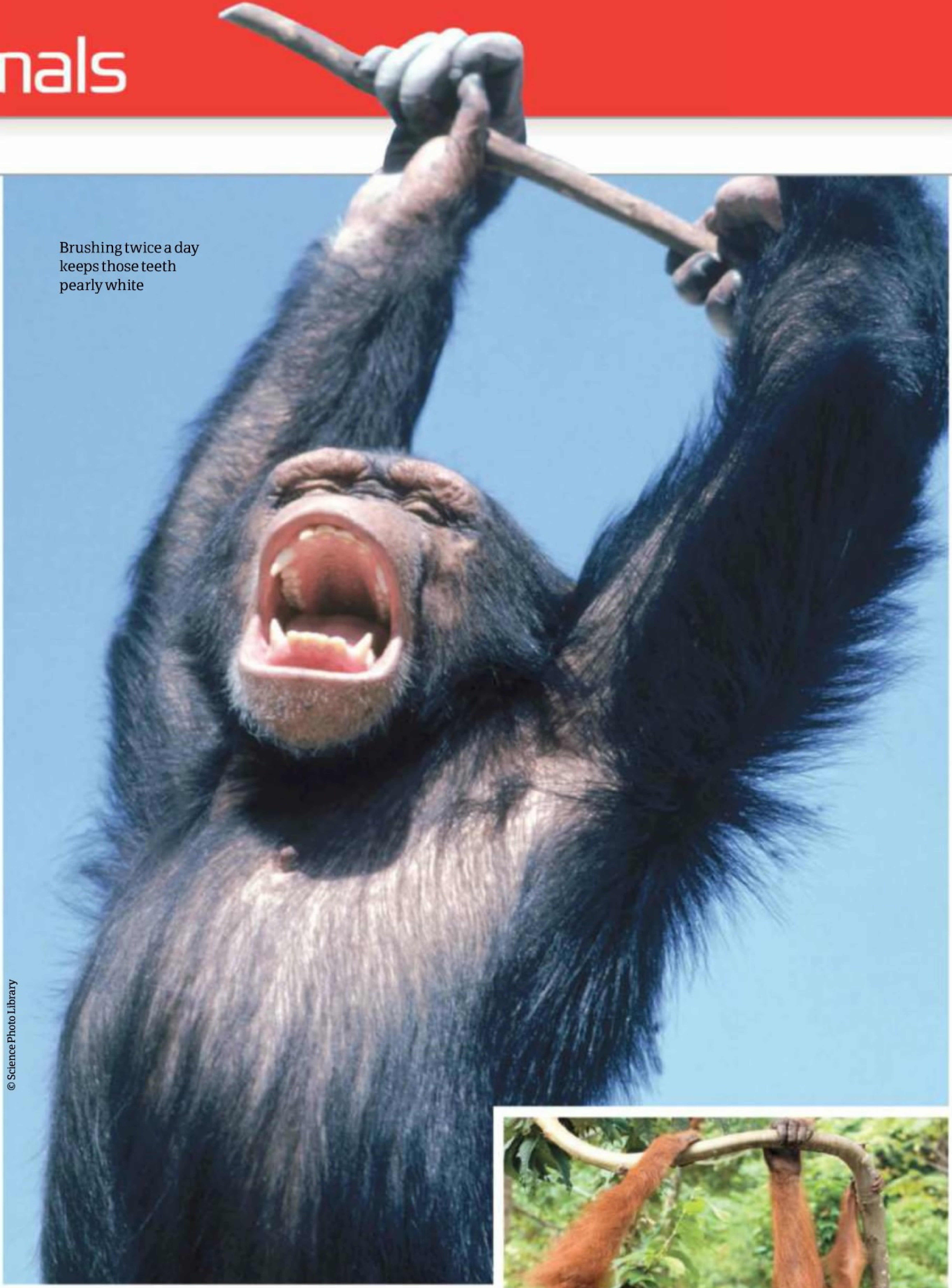
Wise monkeys

Monkey see monkey do

Primates have binocular vision and fingers and thumbs that can grip small objects with precision. This is useful enough already, but it is their large brains that allow them to explore and manipulate the world around them in more complex ways. Chimpanzees use sharpened sticks to poke for termites and as weapons; gorillas carry a walking stick to gauge the depth of the water as they cross a river; Japanese macaques wash their food in seawater to remove dirt and season it with salt. These behaviours aren't innate; they are passed from generation to generation.

Most primates are highly social, with complicated power struggles and sexual relationships worthy of any soap opera. The New World species form monogamous relationships and look after the young together. In Africa and Asia, only gibbons do this. Old World monkeys and great apes have dominance hierarchies to establish one male in a group with mating access to most of the females.



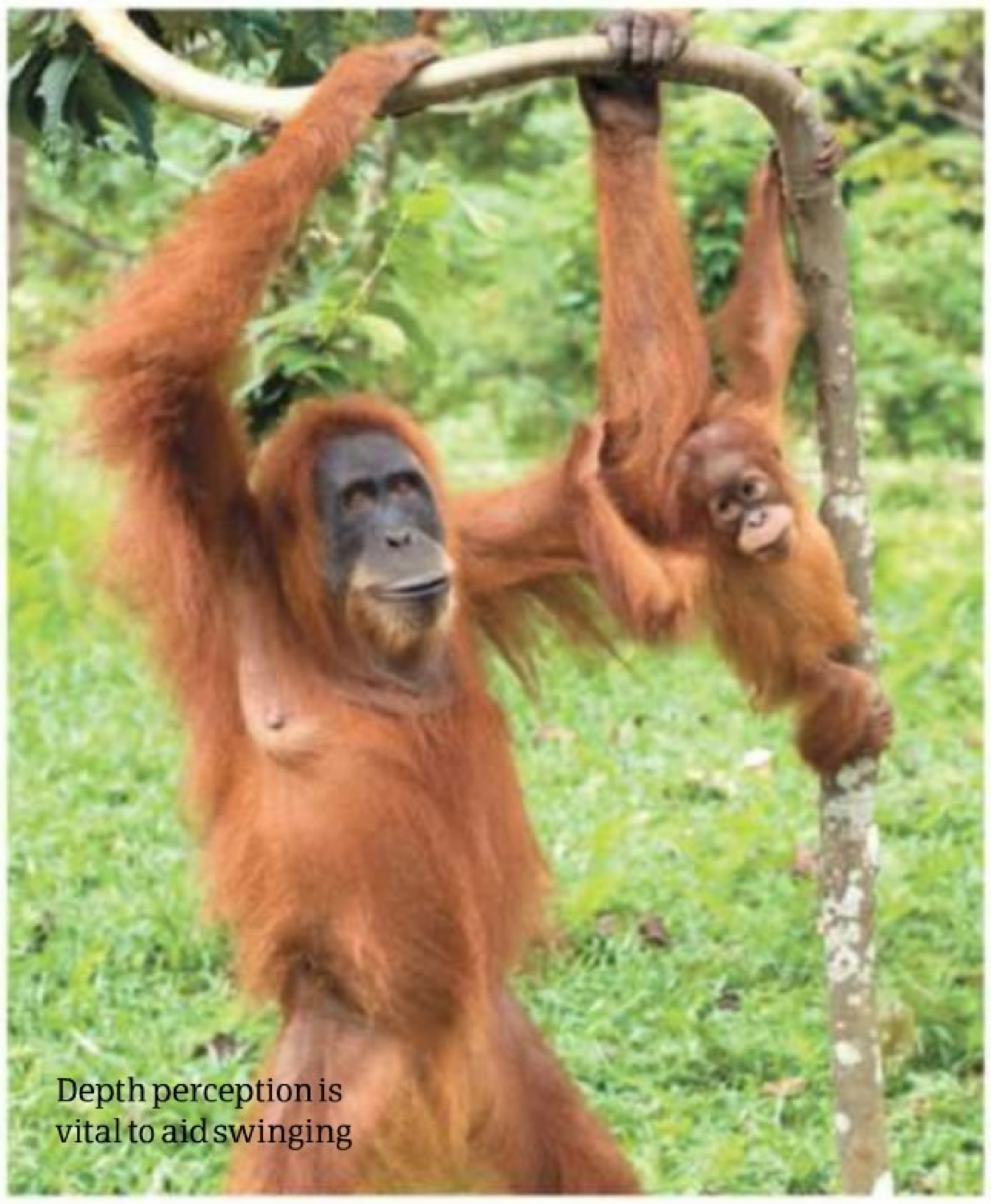
Brushing twice a day keeps those teeth pearly white

© Science Photo Library

Taste the rainbow

The complex, three-dimensional world of the forest makes accurate depth perception essential. This requires forward-facing eyes and a flattened nose that won't get in the way. For this reason primates rely much more on their vision than they do on their sense of smell. Most mammals can see in just two basic colours but primates have evolved a three-colour vision that is sensitive to red, green and blue wavelengths. This allows them to easily distinguish between ripe and unripe fruits.

In New World monkeys, the males all have two-colour vision, which is slightly better for identifying succulent leaves, while most females see three colours, so they can find fruit. Most species gather food co-operatively, to get the best of both worlds.



Depth perception is vital to aid swinging

© Science Photo Library

Head to Head
INTELLIGENT PRIMATES

SMART

© Zyance

1. Orangutan
The fluffy orangutans have been seen using leaves as makeshift megaphones, to amplify the 'kiss squeak' sounds that they make.

SMARTER

© Kabir Bakie05

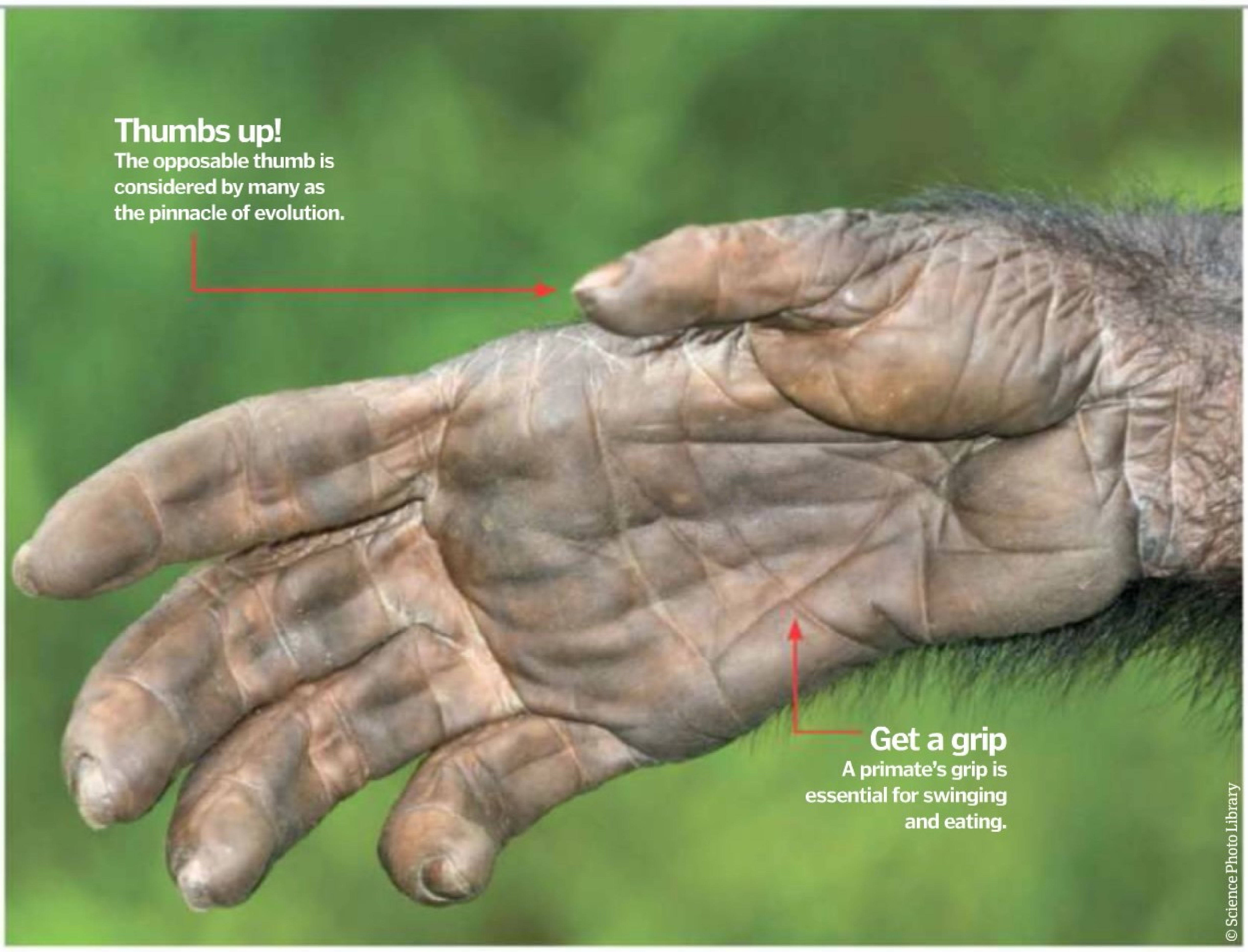
2. Gorilla
Gorillas show complex emotional attachments to each other in the wild and Koko, a female gorilla at San Francisco Zoo, has pet cats.

SMARTEST

© Aaron Logan

3. Chimpanzee
Captive chimpanzees have been taught to use American sign language to ask for food and can remember the numbers one to nine as well as their values.

DID YOU KNOW? [illegible]


Thumbs up!
The opposable thumb is considered by many as the pinnacle of evolution.

Get a grip
A primate's grip is essential for swinging and eating.

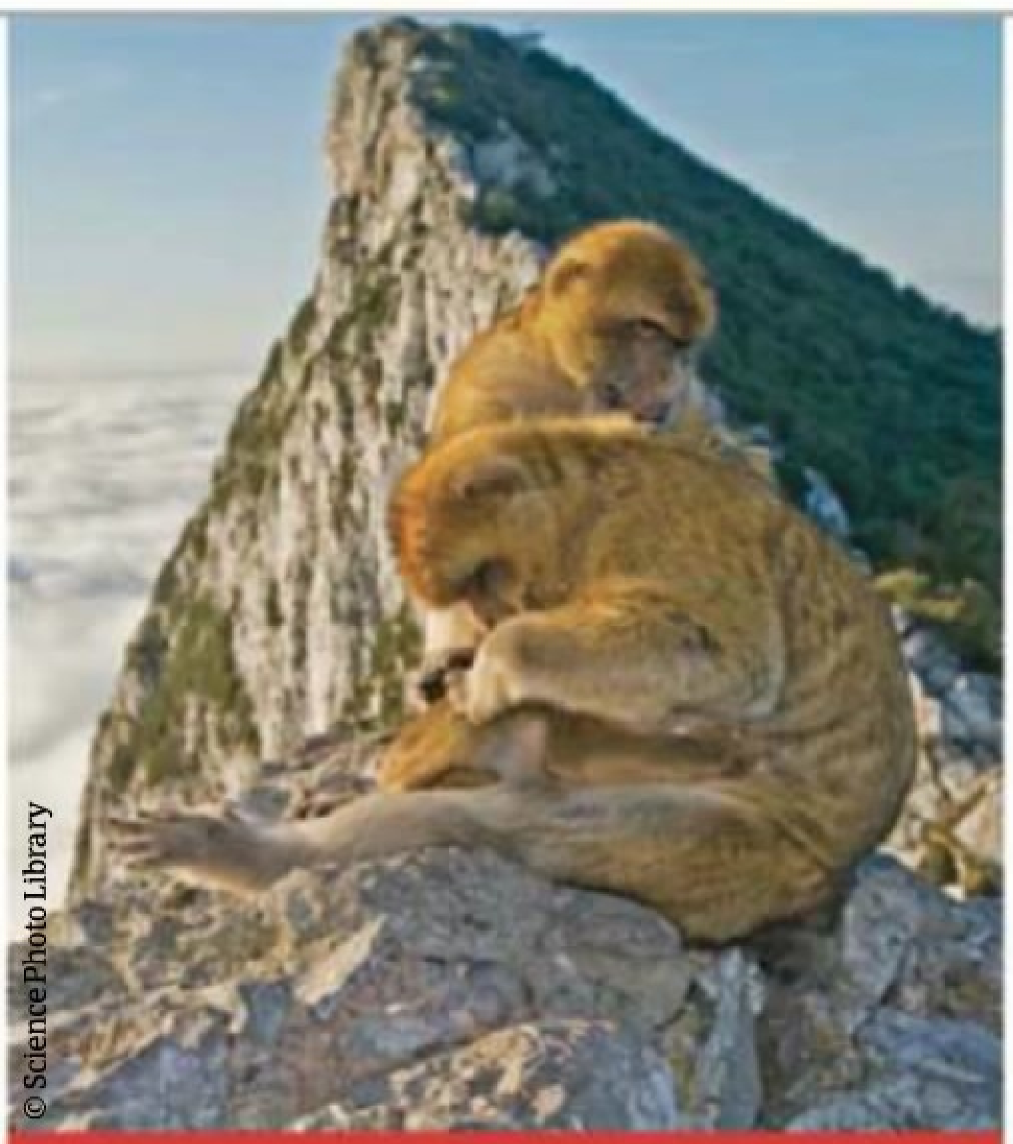
© Science Photo Library

All fingers and thumbs

Primates evolved in the trees and even those species that have since climbed down to solid ground still carry the legacy of hands and feet that were designed to grip branches. Primates have five fingers and toes on each foot with nails, rather than claws, an opposable thumb and often an opposable big toe as well. Primate fingers are much longer than in other mammals and tend to curve inwards when relaxed, so their natural position is a loose grip.

As well as being good at gripping, primates have long arms with very freely rotating shoulders and wrists. This makes it easy to swing from branch to branch. This form of movement is called brachiation. Gibbons can brachiate at 55km/h, travelling 6m with each swing.

"Can you bring a cup and saucer next time"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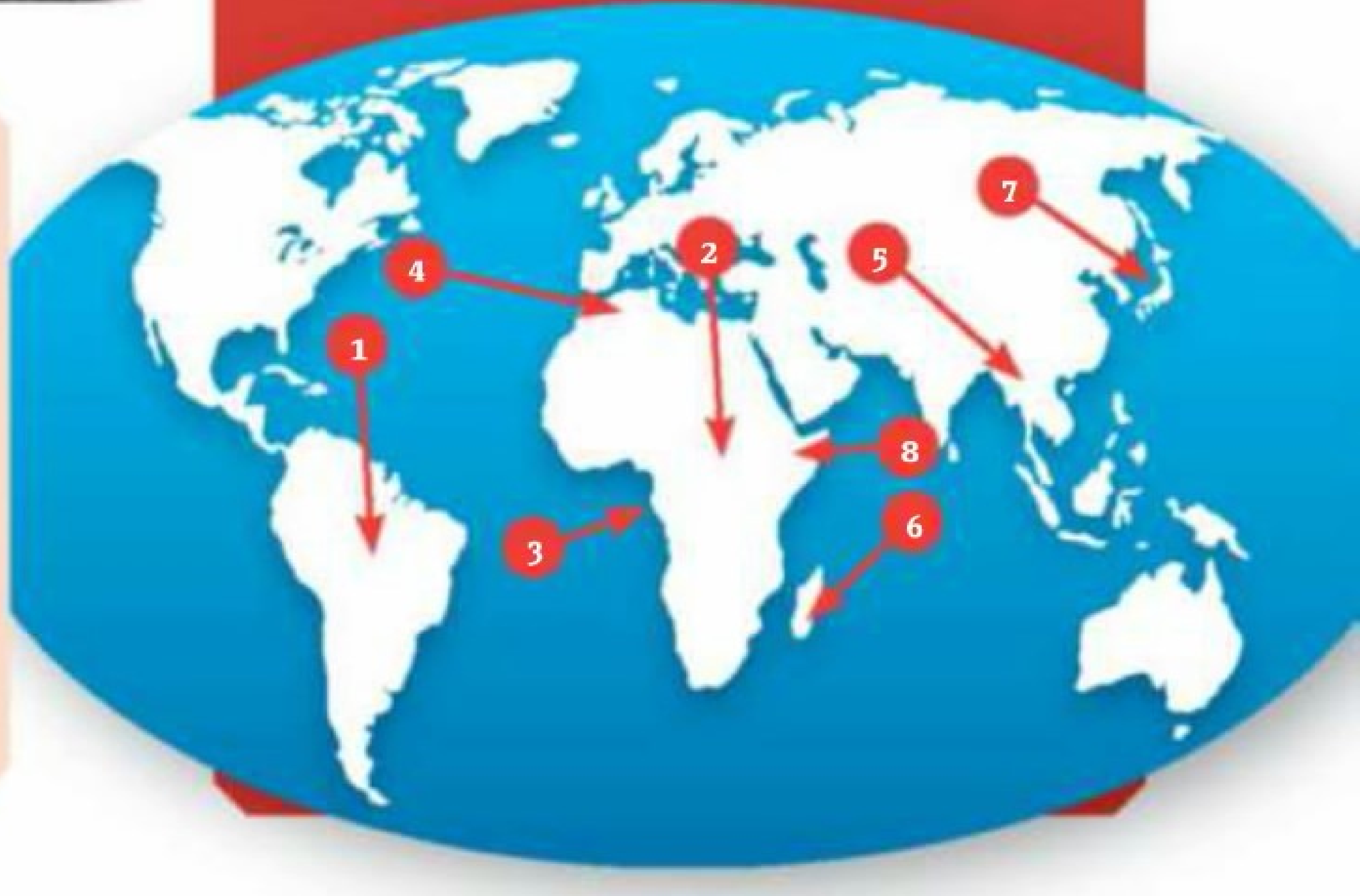
Where do they live?

Primates evolved from tree-dwelling animals. In South America, where forests tend to be very dense with lots of trailing lianas, most species still spend all their lives high in the trees, away from predators. In the Old World, colobus monkeys and gibbons live in the trees but the great apes spend a lot of their time on the forest floor. Baboons and mandrills don't climb much at all.

Primates mostly live in tropical regions, avoid water and are active during the day. But with such versatile animals, there are always exceptions. Galagos, or bushbabies, are nocturnal; Allen's swamp monkey has webbed feet and can swim; and the Japanese macaque lives in an area that is snow-covered for eight months of the year.

ON THE MAP
Where to find primates

1 New World Monkeys – South/ Central America
2 Old World Monkeys, Apes – Sub Saharan Africa
3 Gorillas – Congo
4 Barbary macaques – Atlas Mountains
5 Gibbons – South-east Asia and India
6 Lemurs – Madagascar
7 Japanese macaques – Honshu, Japan
8 Gelada baboon – Ethiopian highlands

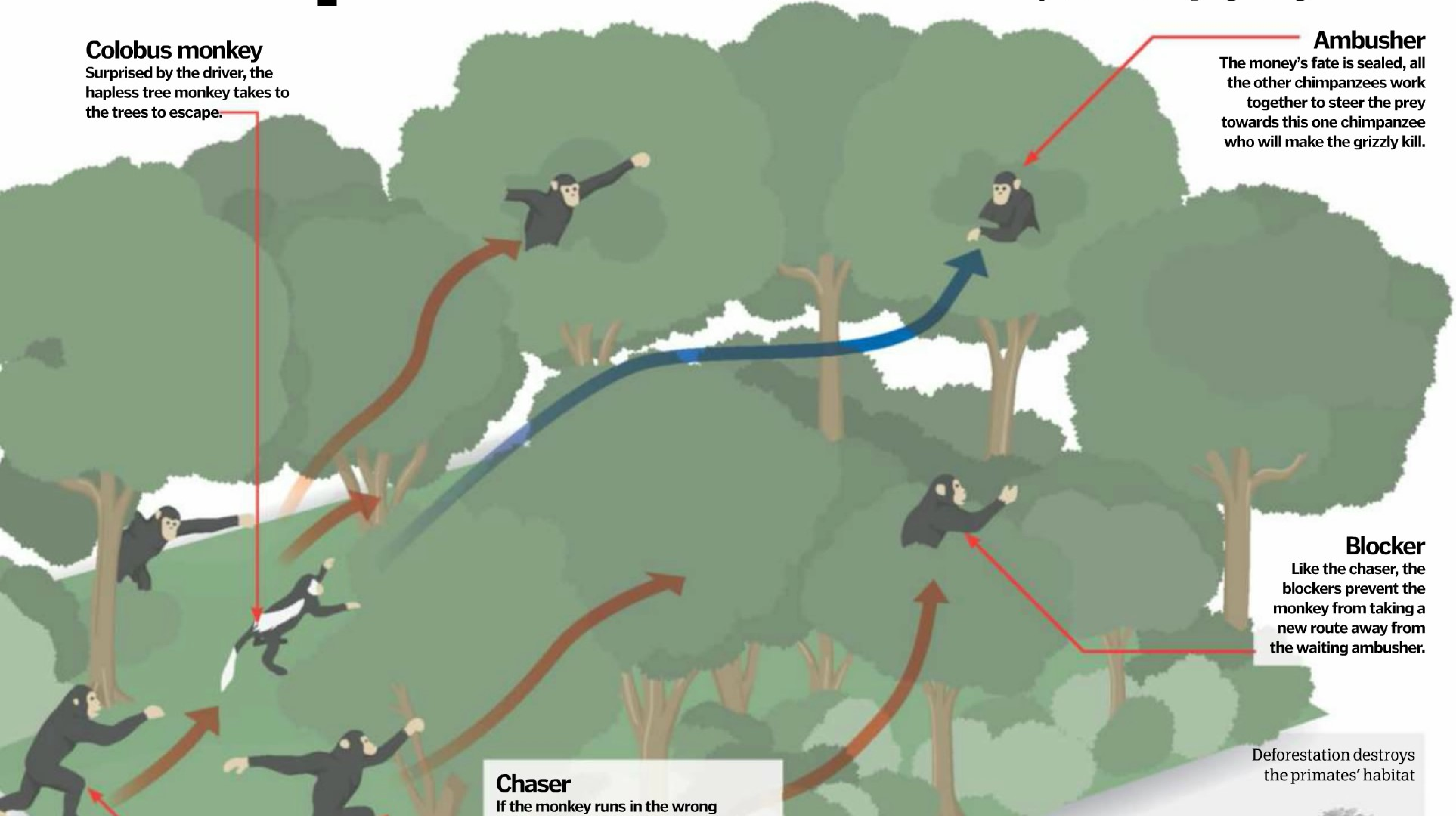


A gripping tail

Apart from the apes, most primates have tails, but *prehensile* tails are unique to the New World monkeys. Prehensile means 'gripping' and the howler, spider and woolly monkeys have a bare pad of skin on the end of their tails that lets them grip food and small objects. The capuchin monkeys don't have this pad and only use their tail as a fifth arm when climbing. Old World monkeys only use their tails for balance.

Chimp chase

Chimps will eat almost anything. In fact, they're partial to the odd small tree-dwelling monkey. In order to catch these swifter, more nimble monkeys, the chimps get organised



Colobus monkey
Surprised by the driver, the hapless tree monkey takes to the trees to escape.

Ambusher
The money's fate is sealed, all the other chimpanzees work together to steer the prey towards this one chimpanzee who will make the grizzly kill.

Blocker
Like the chaser, the blockers prevent the monkey from taking a new route away from the waiting ambusher.

Chaser
If the monkey runs in the wrong direction, chaser monkeys will wait in the trees till it comes near and steer it back on course towards the ambusher.

Driver
A driver chimpanzee startles the monkey and gives chase.

Deforestation destroys the primates' habitat

Threats to primates

More than a third of primate species are critically endangered or vulnerable. Deforestation accounts for a lot of this, mainly through forest clearance for agriculture. But poaching is a significant problem as well. The smaller primates are captured to supply the pet trade, larger animals are hunted for traditional medicine and for their meat. In some African cities, half of all the protein eaten is 'bush meat', which includes primates. Armed conflict in the Democratic Republic of Congo has made poaching much worse because of general lawlessness. Primates reproduce much more slowly than other mammals so populations take a long time to recover.

In Madagascar, at least 15 species of primate have become extinct since humans first settled there 1,500 years ago, including a lemur larger than a gorilla.

There's a good chance his eyes are bigger than his stomach

How do prehensile tails grip?

Learn about the creatures whose tails work like additional limbs

Animal tails perform a vast array of physical functions, from working as a cheetah's counterbalance when cornering at high speeds to delivering a powerful blow in the case of the crocodile, or even communicating emotion, when a pet hound wags its tail. An animal with a prehensile tail, however, has a special ability to grip on to things with its specialised appendage – using it as a kind of extra limb.

Among other animals, fully prehensile-tailed creatures include species from the New World order of primates, which are native to rainforest regions in South America. Here, where the branches of the tree canopy can be widely spaced, animals had to develop a suitable mechanism to assist them in traversing these large gaps in the rainforest over many thousands of years. Spider monkeys, for instance, use their agile tails for additional balance and locomotion when they're swinging through the treetops.

Such a tail is required to suspend the entire weight of a creature and so the skeleton and muscular structure of prehensile tails must be resistant to both torsion and bending, and capable of generating higher forces than regular tails. An opossum, for example, dangles upside down by its tail while using its hands to pick food. The tip of the tail can curl round branches and trunks and some prehensile-tailed mammals even have patches of bare skin or scales – instead of fur – for a non-slip grip on surfaces such as branches.

Spider monkeys spend a lot of their time in the trees so the extra grip a prehensile tail affords can prove a real asset

Beaver dams

We explore how these aquatic mammals design and construct their habitats

Food fuel
Beavers are among the largest rodents on Earth. They live on a herbivore diet, eating leaves, bark, twigs, roots and aquatic plants.

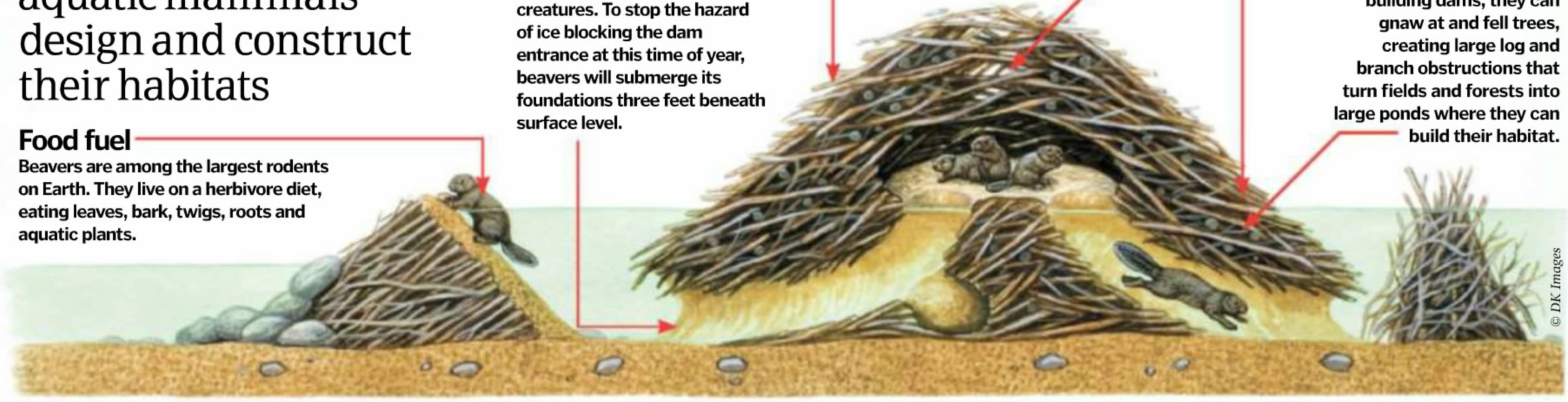
Home sweet home
A beaver's lodge, often found in the middle of a pond, is accessible only by water. These dwellings are home to extended families.

Safe depths
Winter seasons are perilous for all aquatic creatures. To stop the hazard of ice blocking the dam entrance at this time of year, beavers will submerge its foundations three feet beneath surface level.

Standing tall
The average height of a beaver lodge reaches up to six feet tall, with an average depth of water behind the dam of four to six feet. This makes it a great place to look out for predators, and keeps it a safe distance from shore.

Made to last
The thickness of the dam can measure up to five feet or more. The length depends on the width of the habitable stream, averaging 15 feet. This makes for a very sturdy home in all weather conditions.

Rodent renovation
Renovation is the name of a beaver's game. Apart from building dams, they can gnaw at and fell trees, creating large log and branch obstructions that turn fields and forests into large ponds where they can build their habitat.


© DK Images

Beavers are aquatic mammals with a keen affection for engineering, demonstrated in the construction of their artificial dam habitat. This ingenuity is one of nature's greatest wonders, and has been happening for well over 10 million years. Fundamentally, the building of a dam suits the natural instinct of this species. The beaver is an adapted swimmer, that is fairly immobile upon land. This makes it susceptible to predators such as the bear.

Their strong aquatic skills make deep water habitats far more secure. Skilled teams of constructer beavers, usually working in pairs, can build a dam in a matter of days. The dam itself is constructed from an eclectic mix of natural materials, including rocks, wet grass, wood and mud to build the superstructure. A minimum level of three feet is required to keep the dam's underwater entrance from freezing over in winter. A beaver's dam will vary in construct and design, dependent on water speeds in the river. If the dam is straight, then the water current is slow. If it's curved, the water current is fast moving.

Duck-billed plat

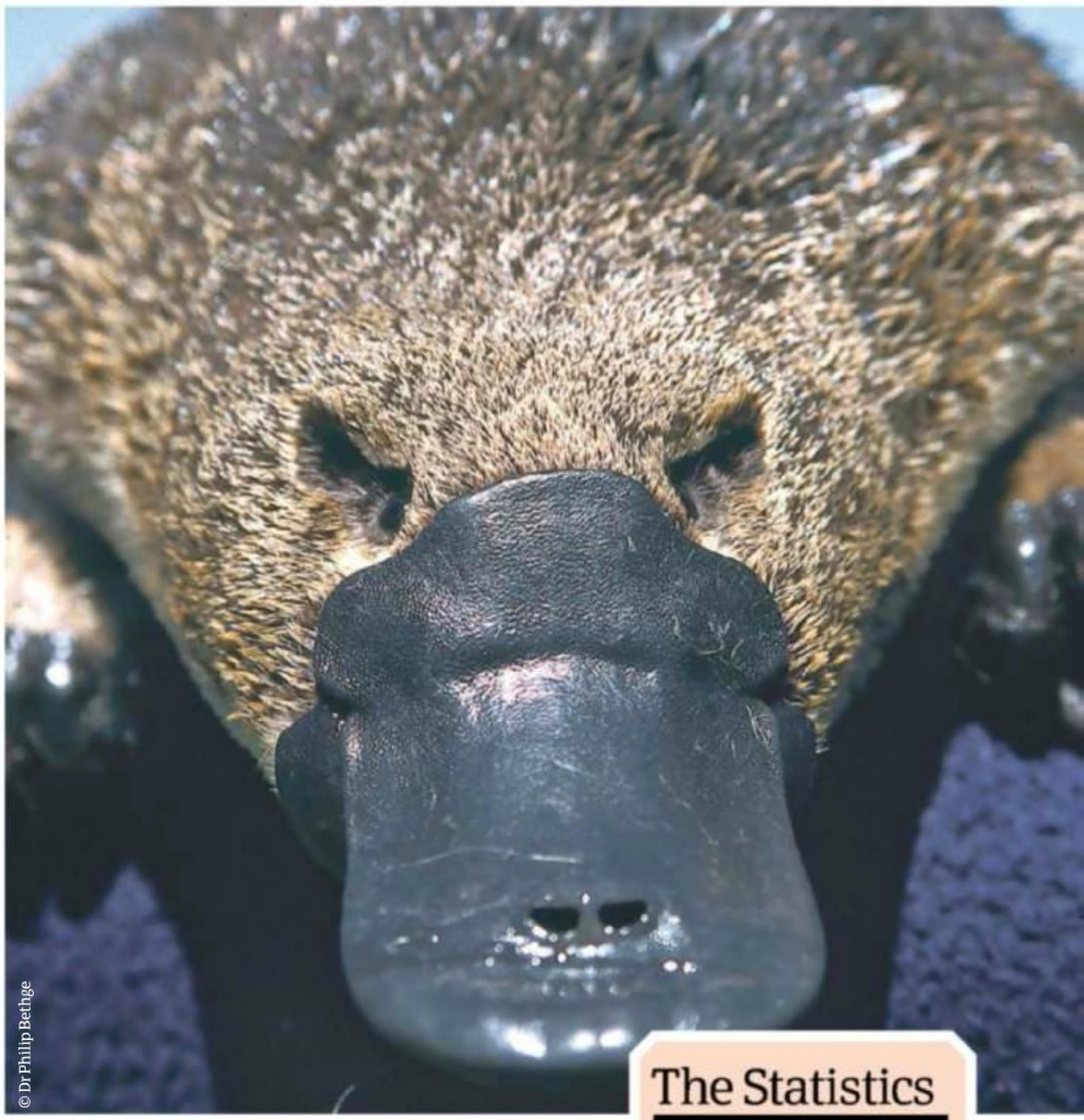
Is it a beaver? Is it a duck? Is it a lizard? No, it's something entirely different…

The duck-billed platypus is a member of the class of primitive mammals called the monotremes, which is a rare order that includes platypuses and just four species of spiny anteater.

Monotremes are oviparous, which means they reproduce by laying eggs that develop and hatch outside the mother's body, rather than giving birth. For around ten days, the mother incubates the egg alone in her burrow by keeping it warm in a pouch between her body and her tail. When the helpless, blind baby – commonly known as a puggle – hatches it will be hungry, and while female platypuses don't have teats like other mammals, they can still suckle their young. Milk glands that are tucked away in a groove inside the pouch on her abdomen produce pools of nutritious milk. The female nurses the puggle for several months until it can both see and swim independently.

The platypus was built for underwater activities: it has a long streamlined body, waterproof fur, paddle-like feet as well as tricks for feeling around in the dark and remaining below the surface for as long as possible. While hunting in rivers and lagoons, the platypus uses its webbed front feet to propel itself through the water and its rear feet and flat, beaverish tail to steer. The creature can remain underwater for several minutes due to the folds of skin that form watertight seals over its eyes, ears and nostrils.

Another distinguishing feature of the platypus is the fact that adult males have a poisonous spur on the hind leg, which can deliver a nasty sting. The spur is used during tussles for territory or mates and in defence against predators, making the male platypus a very nasty adversary.



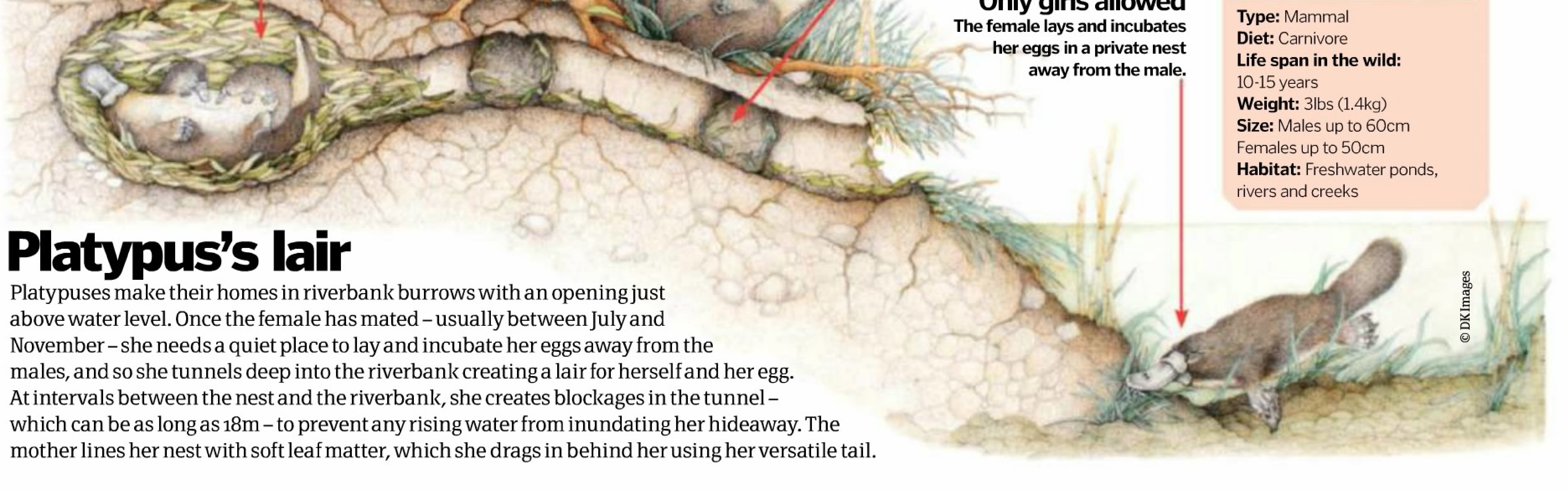
© Dr Philip Bethge

The Statistics

Duck-billed platypus

© Peter Scheunis

Type: Mammal
Diet: Carnivore
Life span in the wild: 10-15 years
Weight: 3lbs (1.4kg)
Size: Males up to 60cm
Females up to 50cm
Habitat: Freshwater ponds, rivers and creeks



Home sweet home
The female spends ten days in her nest and makes it cosy by lining it with soft leaves.

Keep out
To prevent water from flooding the nest and to regulate humidity, Mrs Platypus builds blockages along the tunnel to her nest.

Only girls allowed
The female lays and incubates her eggs in a private nest away from the male.

© DK Images

Platypus's lair

Platypuses make their homes in riverbank burrows with an opening just above water level. Once the female has mated – usually between July and November – she needs a quiet place to lay and incubate her eggs away from the males, and so she tunnels deep into the riverbank creating a lair for herself and her egg. At intervals between the nest and the riverbank, she creates blockages in the tunnel – which can be as long as 18m – to prevent any rising water from inundating her hideaway. The mother lines her nest with soft leaf matter, which she drags in behind her using her versatile tail.

Head to Head VENOMOUS MAMMALS

ELBOW SECRETION

1. Slow loris

The toxin produced by this primate is secreted from a gland in the elbow. It sucks the venom into its mouth and then either licks its babies to deter predators, or bites its foes.

NEUROTOXIN

© Gilles Gonthier07

2. Northern short-tailed shrew

This shrew can paralyse its prey with its venomous saliva. A neurotoxin, which acts on the nerves, is secreted from a gland in the mouth.

ACID

3. Pangolin

The scaly pangolin is another mammal that can emit a noxious substance in a similar way to the skunk. The pangolin gives off a foul-smelling acid from glands near its rear end.

DID YOU KNOW? [illegible]

ypuses

Amazing platypus characteristics

Okay, so if you list the distinguishing features of our friend the platypus you have a medley of traits unique to only a few members of the animal kingdom. Take their webbed feet and rubbery bill, for instance – both examples of a duck's distinctive appearance. Or the beaver-like fur covering all but its bill and feet.

And how about those legs, which protrude from the side of the body, giving the platypus a lizard's gait? Such borrowed characteristics make the platypus one of the weirdest animals waddling around the southern hemisphere. Many creatures all rolled into one quite curious mammal.

The male of the species is more deadly!

For self-defence, both sexes develop sharp calcaneus spurs on their hind legs. These growths are not fixed to the heel; they are attached to a separate bone that allows them greater freedom to move.

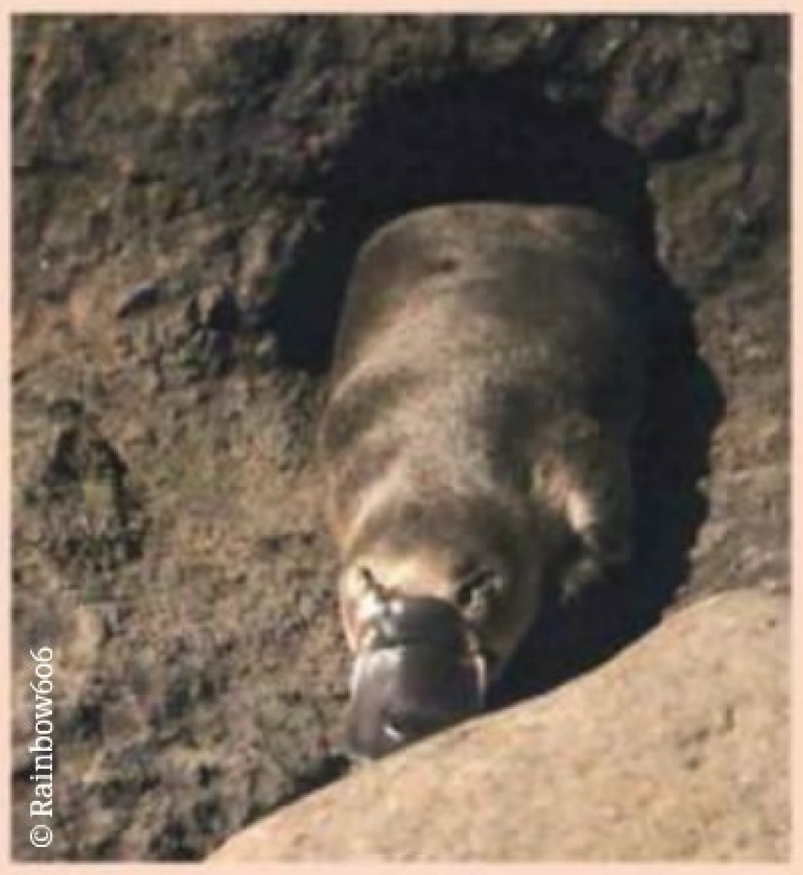
However, only the spurs of the males are venomous and capable of causing immobilising pain or death to small animals. The venom in the spur is unique to the platypus and is composed of special chemical proteins that can cause severe pain and swelling in the victim as well as lowering their blood pressure. The poison is produced in the crural venom gland in the upper thigh and is connected to the sharp end of the spur by way of a tiny duct. The female's spur, on the other hand, doesn't develop fully, and falls off after a year.

The duck-bill and electroreception

Since duck-billed platypuses are mainly crepuscular – that is, they're mostly active during the twilight hours of the early morning and late evening – you might assume they have excellent eyesight for hunting.

And you'd be right; despite the fact they have very small eyes, they do have very keen eyesight. However, the platypus actually keeps its eyes shut when hunting underwater. So to stalk its prey, a platypus instead uses its highly sensitive bill. Although this may resemble the bill of a duck, it's covered with soft leathery skin that contains approximately 40,000 tiny receptors that can detect the faint electric fields produced by small animals buried in the riverbed.

By sweeping its bill from side to side, the duck-billed platypus can sense the direction of its lunch, which it will hungrily dig out of the mud with its spade-like bill.



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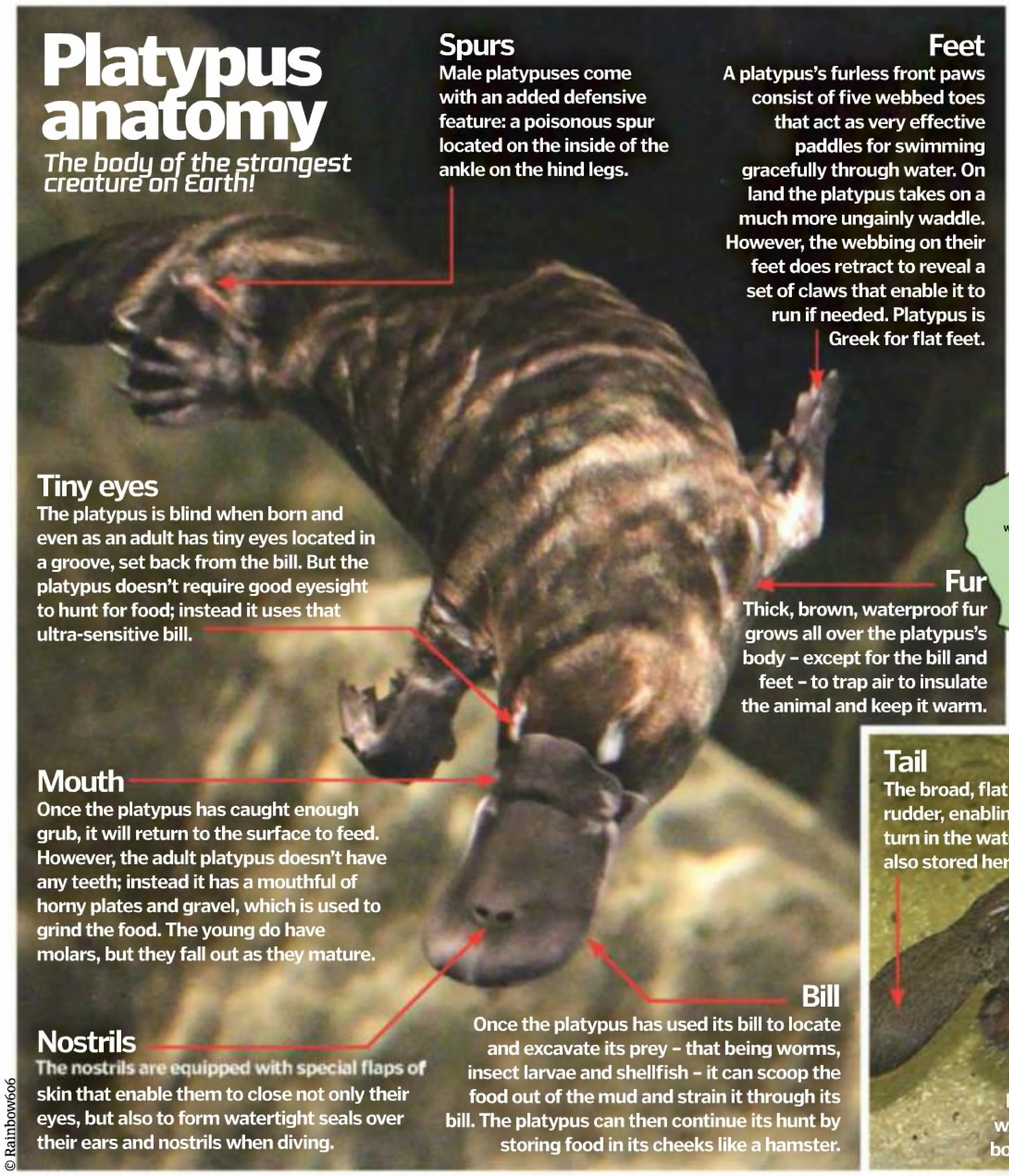
Platypus anatomy

The body of the strangest creature on Earth!



Spurs
Male platypuses come with an added defensive feature: a poisonous spur located on the inside of the ankle on the hind legs.

Feet
A platypus's furless front paws consist of five webbed toes that act as very effective paddles for swimming gracefully through water. On land the platypus takes on a much more ungainly waddle. However, the webbing on their feet does retract to reveal a set of claws that enable it to run if needed. Platypus is Greek for flat feet.

Tiny eyes
The platypus is blind when born and even as an adult has tiny eyes located in a groove, set back from the bill. But the platypus doesn't require good eyesight to hunt for food; instead it uses that ultra-sensitive bill.

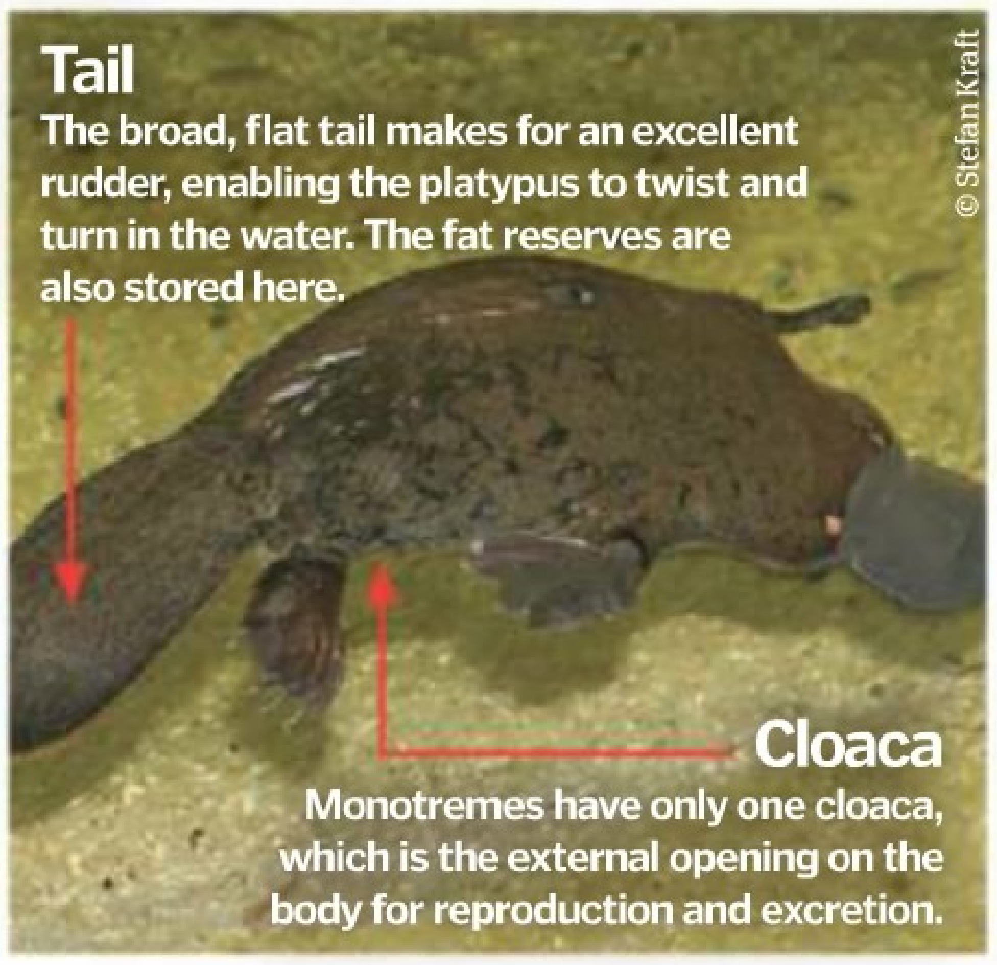
Fur
Thick, brown, waterproof fur grows all over the platypus's body – except for the bill and feet – to trap air to insulate the animal and keep it warm.

Mouth
Once the platypus has caught enough grub, it will return to the surface to feed. However, the adult platypus doesn't have any teeth; instead it has a mouthful of horny plates and gravel, which is used to grind the food. The young do have molars, but they fall out as they mature.

Nostrils
The nostrils are equipped with special flaps of skin that enable them to close not only their eyes, but also to form watertight seals over their ears and nostrils when diving.

Bill
Once the platypus has used its bill to locate and excavate its prey – that being worms, insect larvae and shellfish – it can scoop the food out of the mud and strain it through its bill. The platypus can then continue its hunt by storing food in its cheeks like a hamster.

© Rainbow606



Tail
The broad, flat tail makes for an excellent rudder, enabling the platypus to twist and turn in the water. The fat reserves are also stored here.

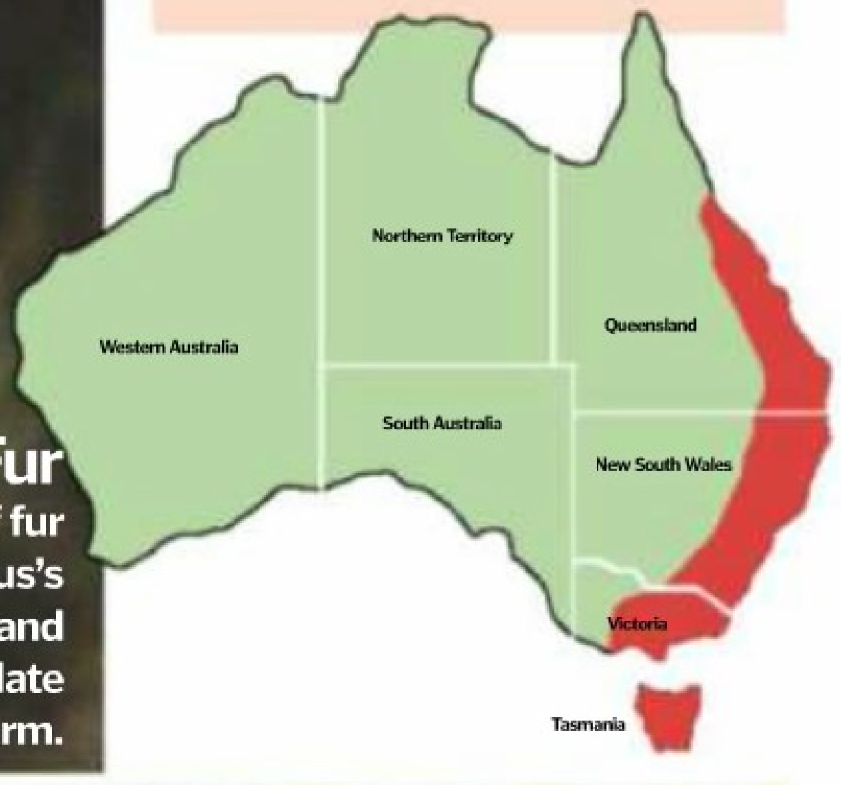
Cloaca
Monotremes have only one cloaca, which is the external opening on the body for reproduction and excretion.

© Stefan Kraft

ON THE MAP

Where the platypuses roam

Platypuses live in burrows in the freshwater creeks and lagoons the length of the eastern side of Australia and are also common throughout Tasmania.



Domestic cats

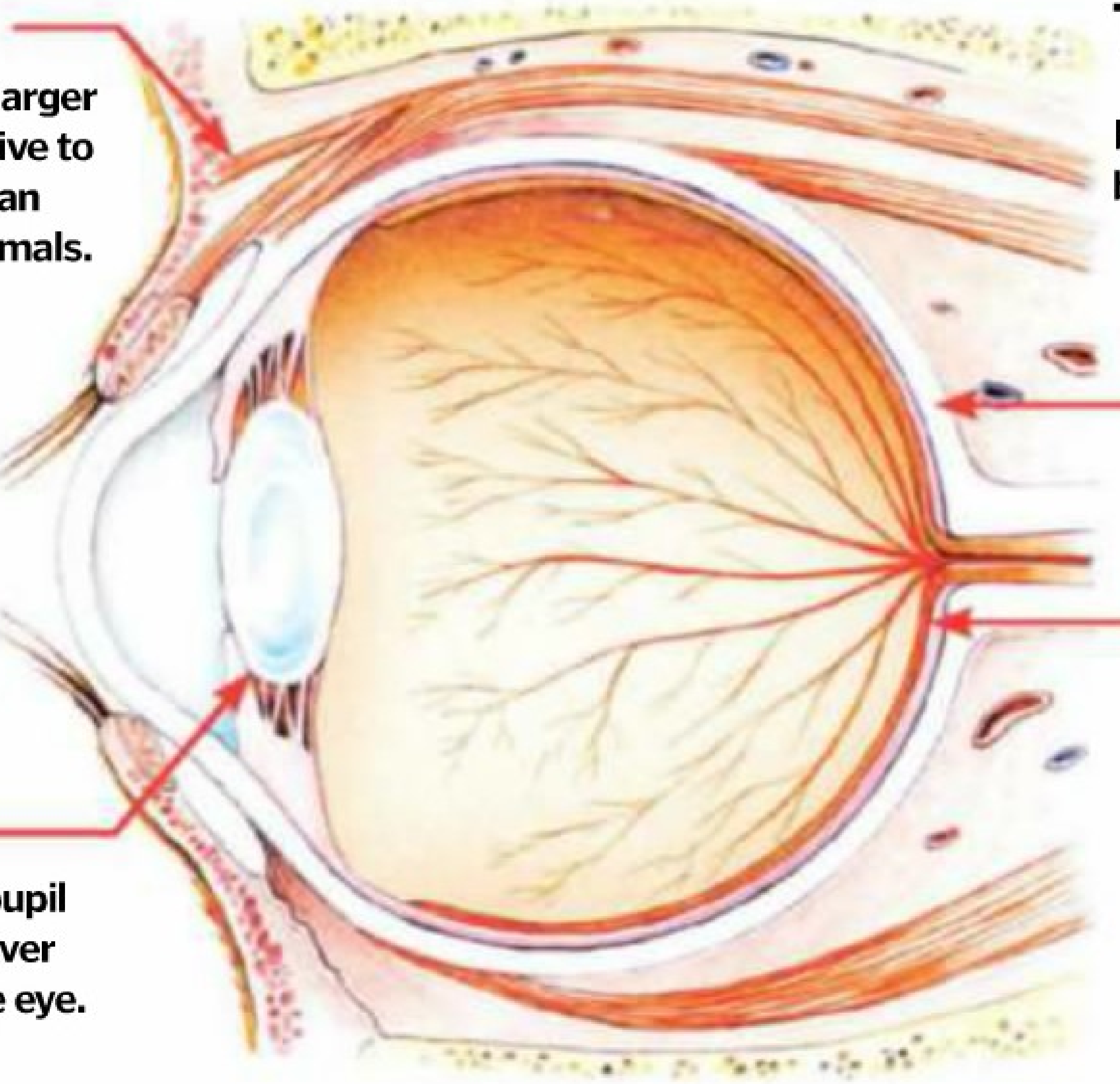
The tricks, skills and amazing features of the world's most popular pet

Cats originated in the Middle East, descended from the African wildcat. They were domesticated sometime in the Stone Age, probably around the development of agriculture, when grain stores began to attract rats and other pests to human settlements. Cats in the wild make almost no sounds to one another, but among humans they have a wide repertoire of purrs, hisses, mews and yowls. These are all designed to communicate with us and research has shown that stroking a cat stimulates the hormone oxytocin in humans, which helps us feel relaxed and happy. A 9,500-year-old grave in Cyprus has been found of a Neolithic human buried next to a cat. There are now roughly 500 million domestic cats around the world but genetic analysis has revealed that they are all descended from just five females.

Many domestic cats have a semi-feral lifestyle where they will take food from several different households as well as hunting for themselves. To this end, cats still retain most of the hunting skills and instincts of their ancestors. Cats are quite hardy and can get all the water they need from eating meat. Interestingly, they can also drink seawater. Cats mainly hunt at twilight; their eyes can operate with just one-sixth of the light that we would need to see by and their hearing is among the most acute of any mammal. In the UK, cats kill 64.8 million birds a year; indeed, 30 per cent of all sparrow deaths are down to a feline culprit.

HEARING
Cats can point their ears forwards or backwards independently to pinpoint sounds. The complex folds and flaps help with this as well, by cancelling out certain frequencies of sound and amplifying others. Cats can hear frequencies a whole octave higher than even dogs.

How cats' eyes work

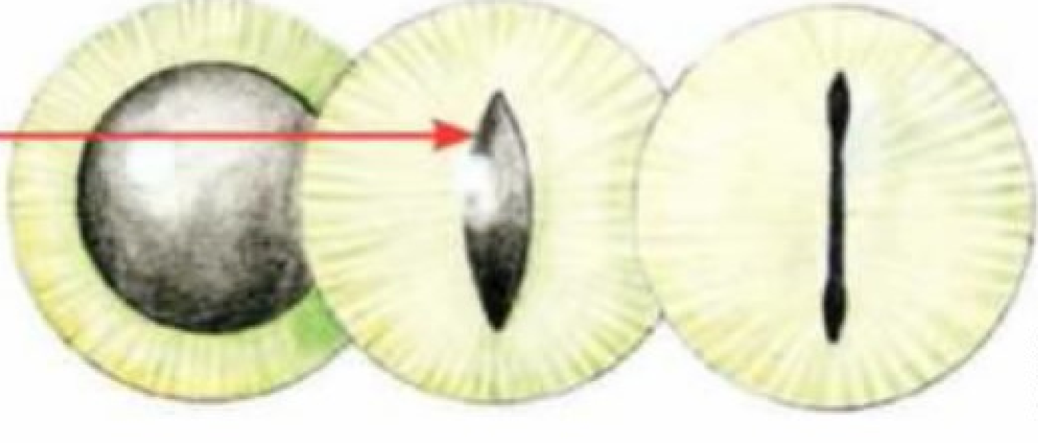


Eye socket
Cats have much larger eye sockets relative to their skull size than most other mammals.

Tapitum lucidum
A reflective layer on the back of the retina. Light is bounced back for another chance to be absorbed.

Pupil
In low light, the pupil can expand to cover almost the whole eye.

Retina
Cats can distinguish blue and yellow-green colours but have limited sensitivity to red.



Slit pupils
To prevent image distortion in bright light, cats contract their pupils to a slit instead of a point.

© DK Images

Head to Head
HAIRY MOGGIES

1. FLUFFY

Maine Coon
According to folklore, this North American breed is the result of feral cats mating with raccoons. Alas, that's a genetically impossible feat.

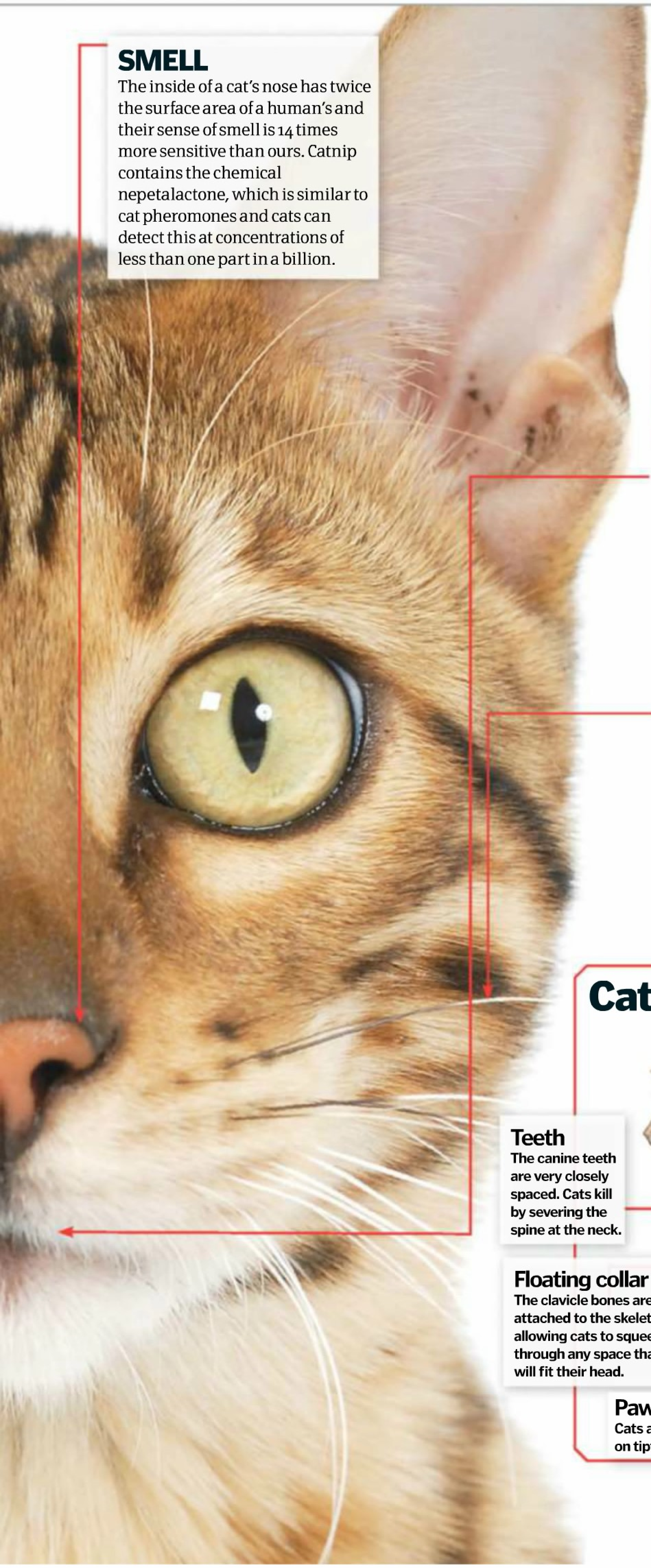
2. FLUFFIER

Turkish Angora
This ancient breed has medium-length fur with no undercoat. In Turkey, the breed is considered a national treasure.

3. FLUFFIEST

Persian
The very long coat is a recessive mutation. Originally Persian cats had longer muzzles, until breeders selected for the flatter face.

DID YOU KNOW? *Cats are extremely tolerant of heat and can survive up to 56°C if they have access to water*



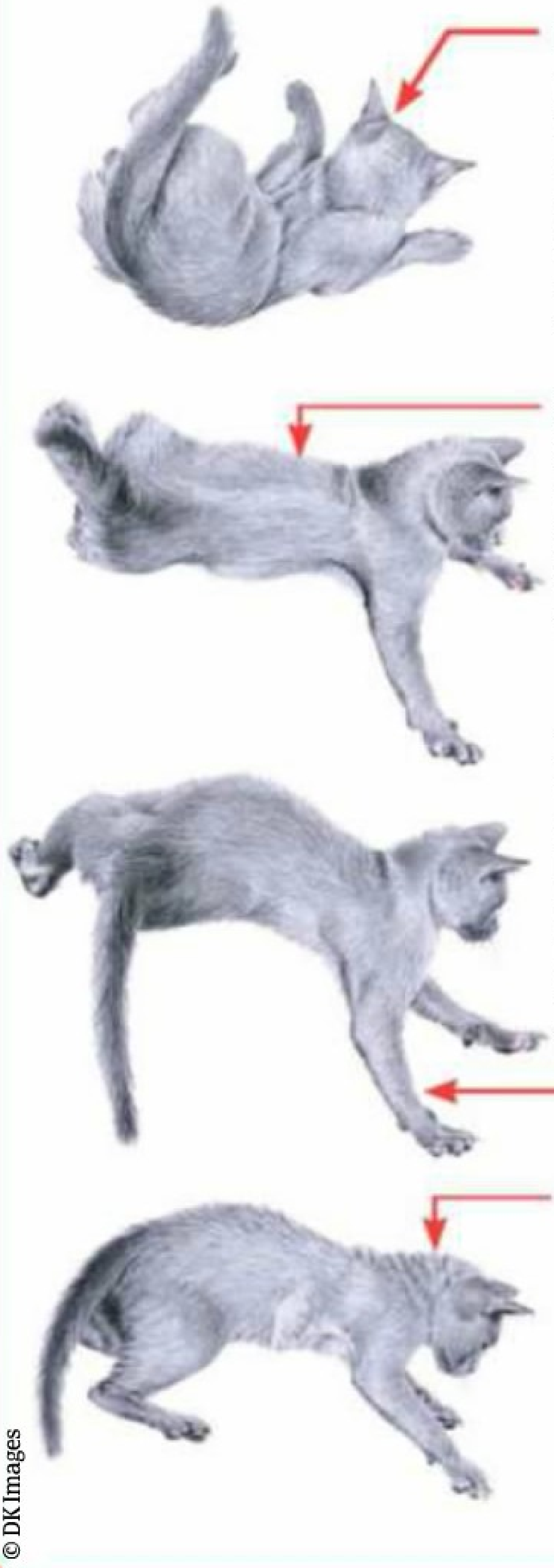
SMELL
The inside of a cat's nose has twice the surface area of a human's and their sense of smell is 14 times more sensitive than ours. Catnip contains the chemical nepetalactone, which is similar to cat pheromones and cats can detect this at concentrations of less than one part in a billion.

© SPL

TASTE
All members of the feline family lack one of the genes needed to be able to taste sweet things. Cats have very rough tongues, but when they drink only the smooth tip is dipped into the water. Cats are lactose intolerant and milk can cause stomach upsets.

TOUCH
Cat whiskers have sensitive nerve endings that allow the animal to build a three-dimensional map from air currents and contact with objects. When a cat bites, the whiskers bend inward to form a basket so that it can pinpoint the location of its prey even when it is too close to see.

How do cats land on their feet?
The self-righting reflex develops at seven weeks old. In a 30cm fall, cats can perform a midair 180° turn



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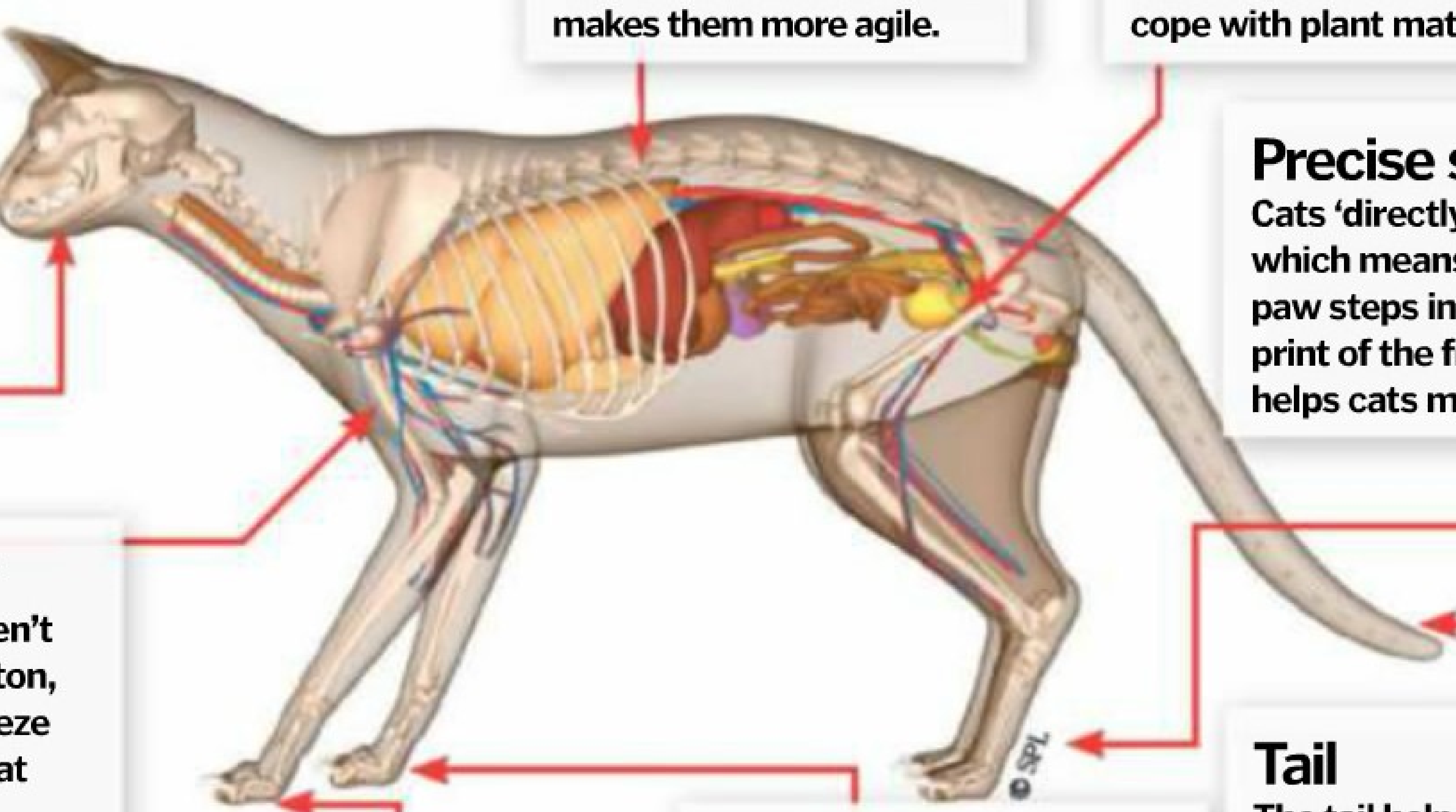
1. Curl up
The cat starts by bending in the middle, so the front and back halves rotate around two different axes.

2. Tuck and spread
The front legs are pulled in and the back legs spread out wide.

3. Half twist
When the spine twists, the front half rotates faster than the back, like an ice skater tucking in for a spin.

4. Repeat
Pulling in the back legs and spreading the front allows the cat to repeat the procedure to rotate the rear.

Cat anatomy



© SPL

Extra vertebrae
Cats have one more thoracic vertebra and two more lumbar vertebrae than humans in their spine. This makes them more agile.

Short intestine
Cats are obligate carnivores. Their short intestine is specialised for digesting meat and can't cope with plant matter.

Teeth
The canine teeth are very closely spaced. Cats kill by severing the spine at the neck.

Precise steps
Cats 'directly register', which means the hind paw steps in the paw print of the front. This helps cats move silently.

Floating collar
The clavicle bones aren't attached to the skeleton, allowing cats to squeeze through any space that will fit their head.

Paws
Cats are digitigrade, which means they walk on tiptoes, rather than the flat of the foot.

Carpal pad
Resembling a sixth toe, this pad on the wrists provides extra grip when landing.

Tail
The tail helps with balance when jumping, but even cats without tails can right themselves if they fall.

Cat paws

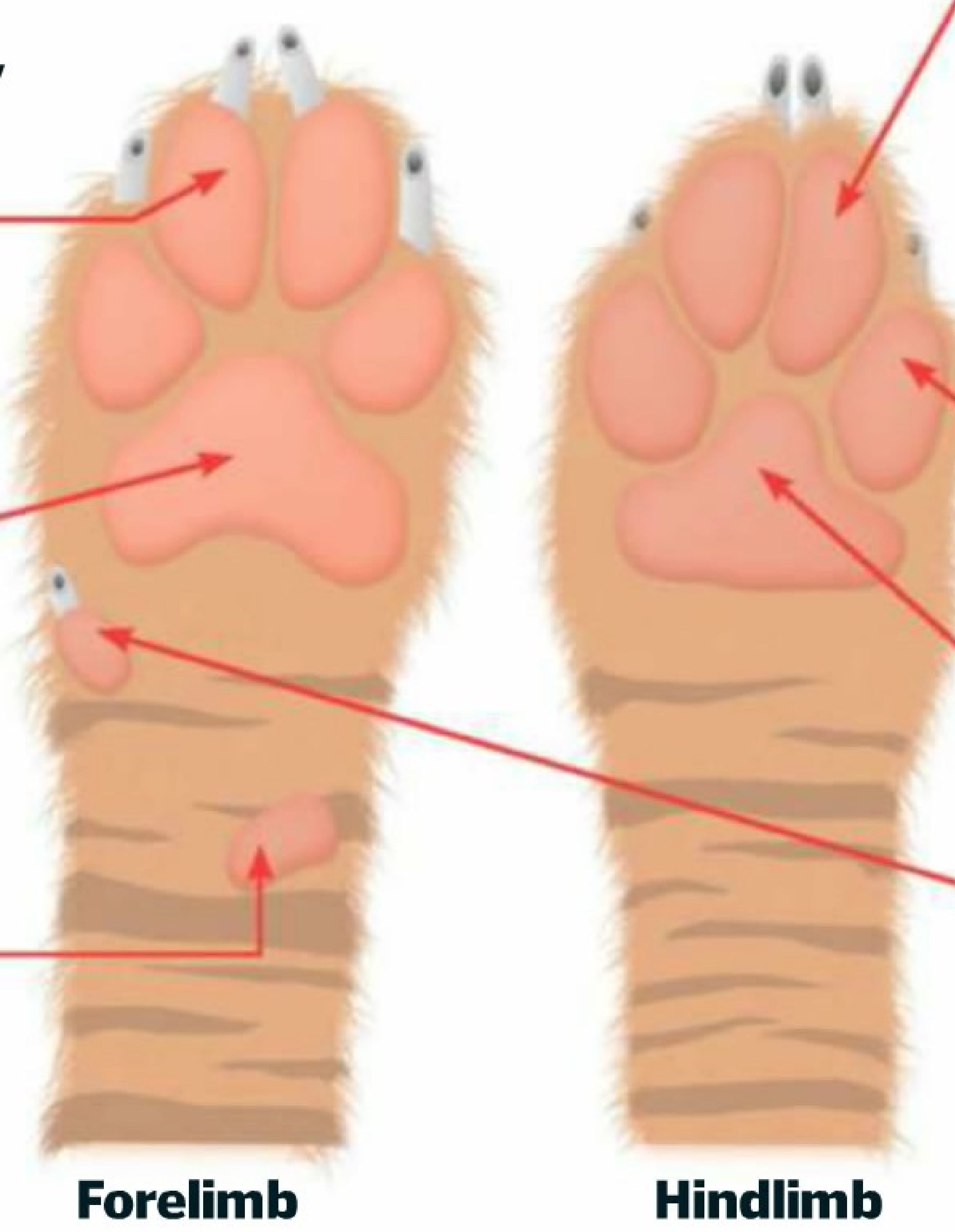
A cat's paws are vital to keep the feline alive and kicking. They can help perform many functions from shock absorbing and self-defence to cleaning, killing and climbing

Unlike other creatures, such as humans who walk on the soles of their feet, cats are digitigrades and walk on their tiptoes. This makes them very agile, quick, and quiet too – hence the phrase 'cat burglar'.

Both front paws have five digits (toes) while the rear two have just four. The back paws are stronger than the front and can better tolerate impacts when running and jumping. For every digit there is a digital pad, which cushions the foot. An additional large pad in the middle of each paw consists of three fleshy lobes to help absorb shocks and support the main leg bone. This is called the metatarsal pad on the hind paws and the metacarpal pad on the fore paws.

As well as the pads, each digit also features a sharp claw. Like human fingernails, the claws grow constantly and are made of keratin protein encased in hard, dead keratin cells. The front claws are usually sharper than the rear ones and to keep them sharp, when not in use the claws are protected by the skin and fur around the paw. Meanwhile, to prevent them growing too long and potentially resulting in painful ingrown claws, cats can keep their claws short by using them for climbing, fighting and self-defence. They can also be trimmed by a vet and the use of a scratching pole will help file them down a bit too.

Paw anatomy



Digital pads

For every toe, or digit, the cat has a hairless digital pad. There are usually five digits on the front foot, which includes the dewclaw, and four digits on the back paw.

Metacarpal pad

These are the large fatty pads located in the middle of the paws. They consist of three lobes and protect the main weight-bearing leg bones.

Carpal pad

These smaller pads, also known as the pisiform pads, are situated on the inside of the wrists further back up the front legs. Pisiform means pea-shaped and relates to the shape of the wrist bone.

Footprints

To reduce the noise they make when walking and to limit the visible tracks they make, cats walk with extreme precision. The rear paw will step pretty much directly where the forepaw was before it left off.

Digital pads

Metatarsal pad

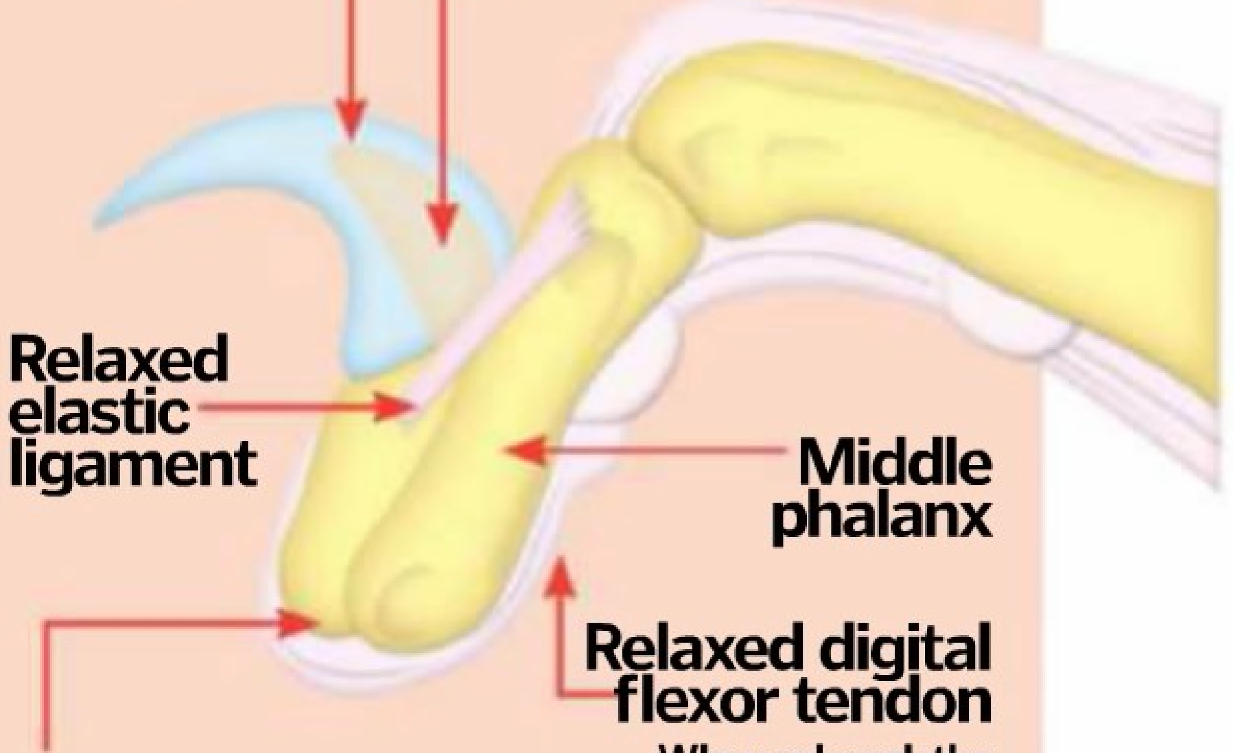
Dewclaw

This is a much shorter toe located further up the leg where it doesn't make contact with the floor. It's like a redundant thumb and has no major function other than possibly to offer stability when running.

Protractile claws

When a cat's paw muscles are relaxed you won't see much of the claws because they are concealed, or retracted, behind the skin and fur of the paw when walking around or lazing in the sun. However, cats are capable of extending, or protracting, their claws for fighting, climbing and scratching if required. When an adult cat decides to tighten its digital flexor tendon – ready for, say, a catfight – the claw extends and becomes much more visible outside the digital pad. Once the cat relaxes its muscles again, the claw will retract back to its normal resting position. Kittens are less aware of taking control of their paw muscles and some young cats cannot retract their claws until they are older.

Claw retracted



Keratin cuticle
The outer cuticle is made of a tough protein called keratin.

Quick
The soft pink dermis tissue within the claw is the quick. It receives the blood supply and is sensitive to pain.

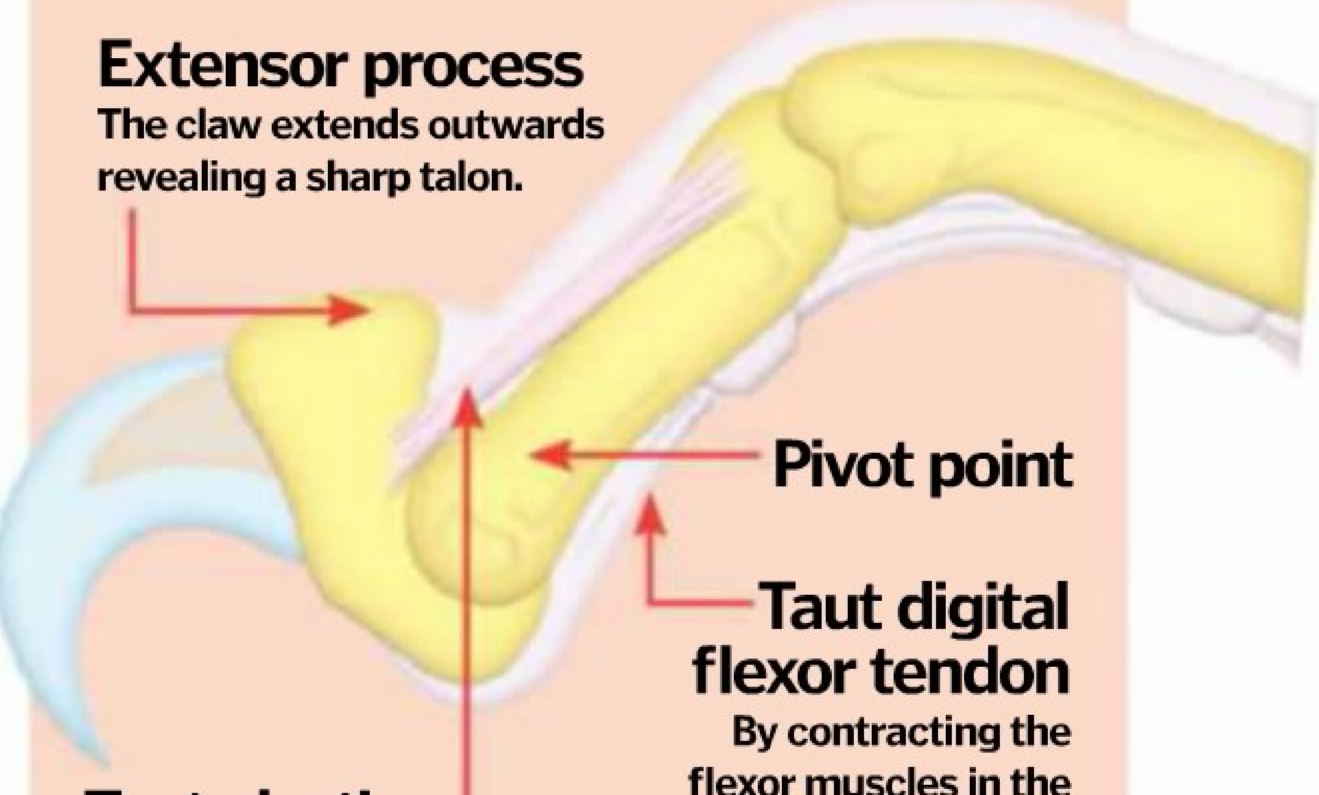
Relaxed elastic ligament

Middle phalanx

Relaxed digital flexor tendon
When relaxed, the claw is pulled up inside the skin and fur, protecting the claw and keeping it sharp.

Distal phalanx
A claw grows outwards from the tip of the last bone on the toe, the distal phalanx.

Claw protracted



Extensor process
The claw extends outwards revealing a sharp talon.

Pivot point

Taut digital flexor tendon
By contracting the flexor muscles in the cat's legs, the tendon beneath the paw – which anchors the claw – is pulled taut. A pivot action causes the distal phalanx to move forward and out, revealing the claw.

Taut elastic ligament
When the cat relaxes its muscles again, the taut elastic ligament will also relax allowing the claw to return to its resting retracted position.

5 TOP FACTS CAT PAWS

Monstrous manicures

1 Onychectomy is the cruel practice of declawing a cat. Another surgical procedure is a tendonectomy, which cuts the tendon that enables a cat to extend its claws.

Polydactyl cats

2 Cats usually have five digits on each front paw and four on the back. However, it's fairly common for some species to develop a mutation that leaves them with up to seven toes.

Which paw are you?

3 Cats have a preferred paw. Of 100 cats tested, 60 per cent had a dominant paw – around 40 were left-pawed and 20 were right-pawed – while 40 per cent were ambidextrous.

Hot footing

4 Cats are covered in fur so they have to sweat through the skin on their paws. Scent glands beneath the front paws also let the cat leave behind its individual scent.

Cat on a hot tin roof

5 Cat paws are very sensitive, they use them to sense not only vibrations and movement but also temperature. Cats are known to put a paw out to test a surface they are unsure of.

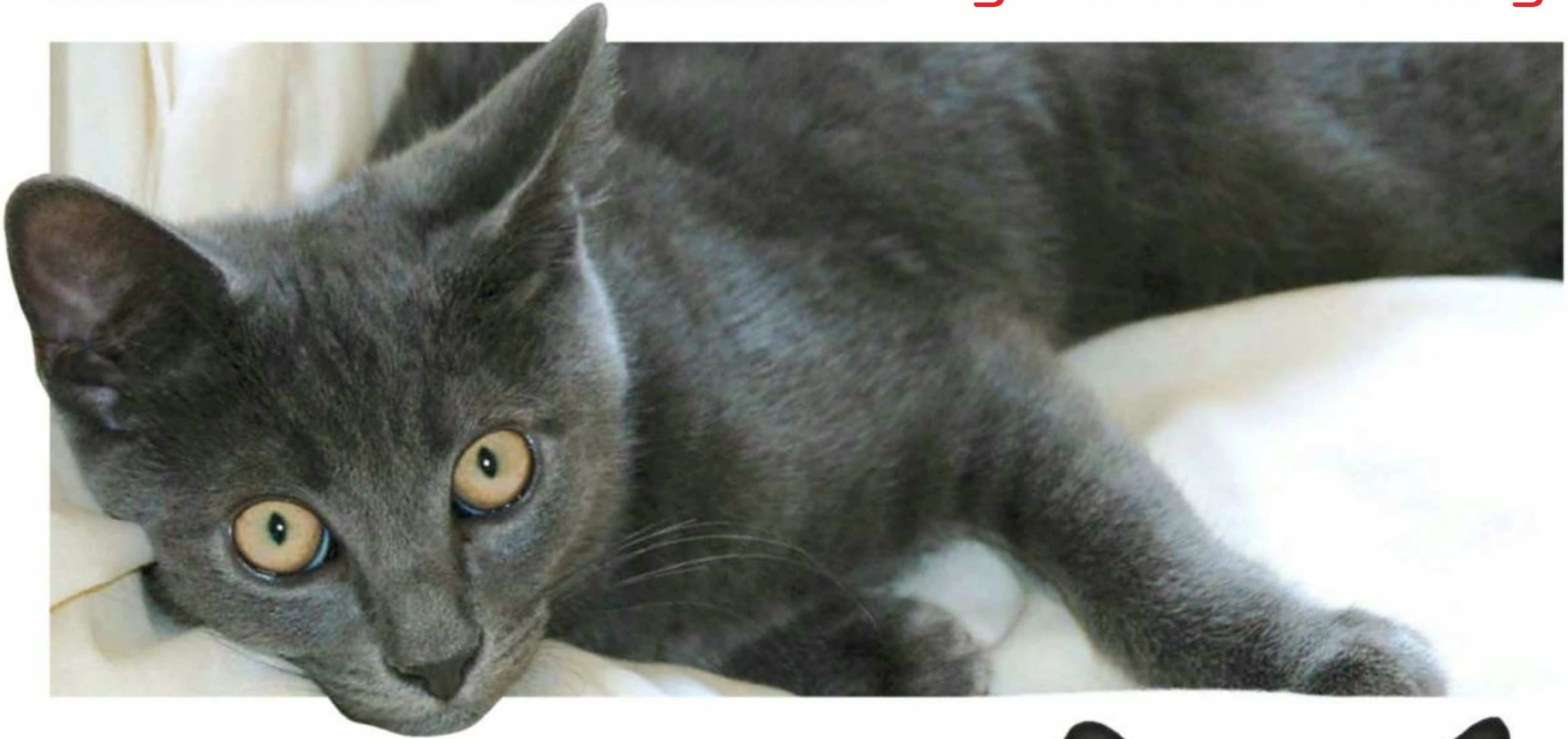
DID YOU KNOW? Catsfoot is a perennial herb with leaves covered in a whitish down and clusters of flowers

Purring explained

What is the noise a cat makes when breathing?

Cats purr both when they inhale and exhale, to create a constant sound. The muscles responsible for creating the purring noise are the laryngeal muscles, which control the opening and closing of space between the vocal cords, the glottis. As air passes through the glottis, the muscles open and close it rapidly to produce the purring noise. A neural oscillator in the brain of the cat is responsible for signalling the muscles to contract and relax. Scientists have shown that the frequency range within which a purr falls – 25 to 150 Hertz – is responsible for stimulating bone growth and healing. A cat will normally purr when it is happy, scared or upset, which might indicate why a cat frequently purrs. In addition, as kittens are born blind and deaf, the vibrations of a purr allow newborns to locate their mother.

> "The frequency range within which a purr falls is responsible for stimulating bone growth and healing"



Animal territory marking

How do animals stop others from invading their living space?

There are chemical signals all around the world that humans can barely notice. However, many animals are not only sensitive to these tastes and smells, but they are also able to secrete them as well. A scent known as a pheromone is one such chemical, given off by animals to influence the physical and mental behaviour of others in the same species. They are normally produced in microscopic amounts but their effect can be powerful.

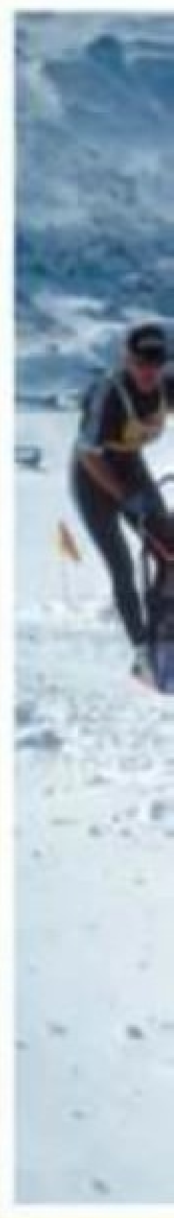
Animals patrol a territory in which they plan to mate or inhabit and mark certain objects or the ground with their pheromone. Other animals arriving at the territory can detect the pheromone by smell. This lets them know the animal wants some privacy and may become aggressive if its living quarters are infringed upon.

There are many ways an animal can produce pheromones, such as glands on their body or leaving excretion in certain areas. Pheromones allow an animal to alert others of their readiness to breed.

There's a whole world under its nose

Dogs

What makes man's best friend tick?

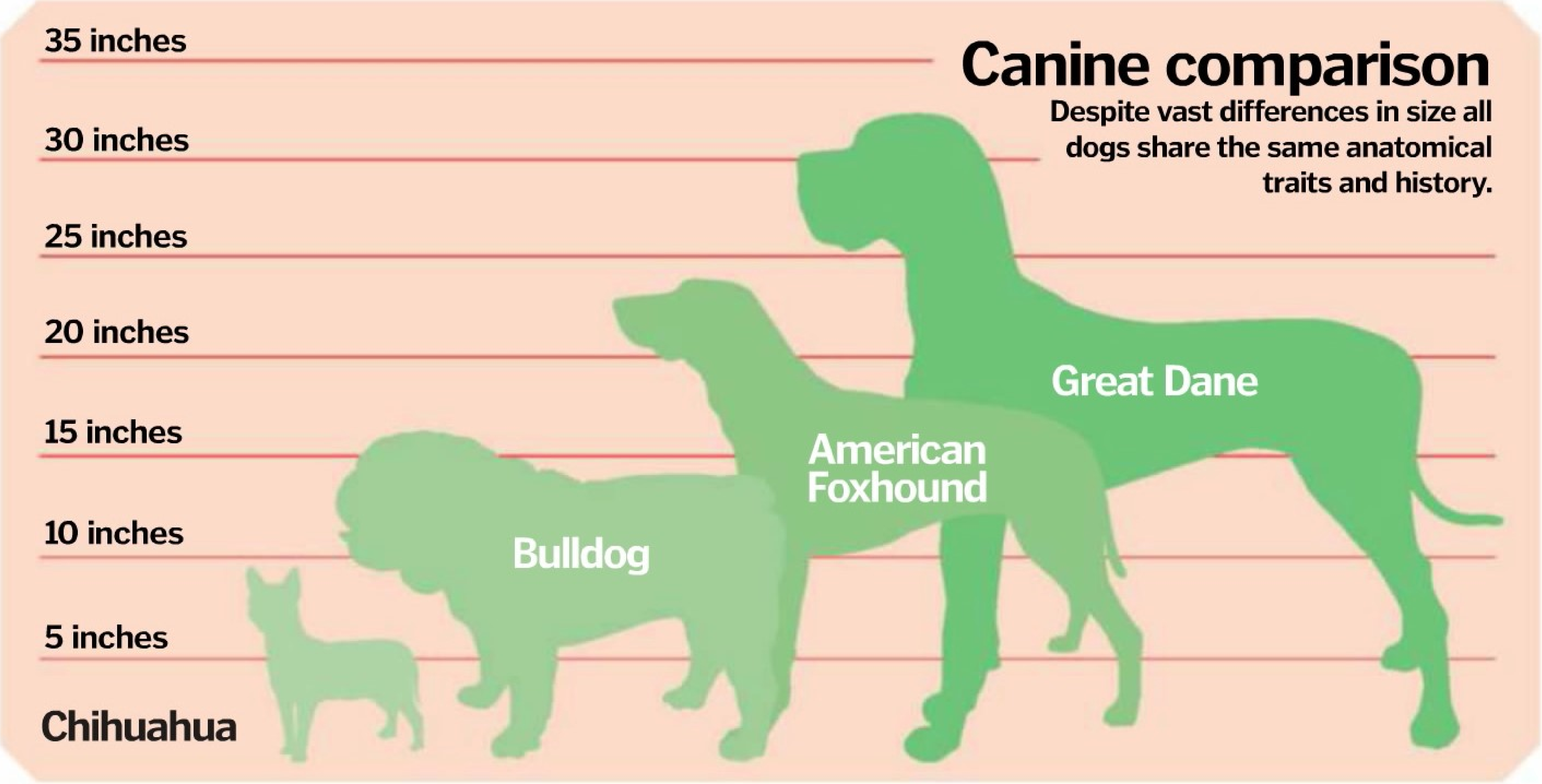


Dogs evolved around 15,000 years ago in China and are descended from the Asian wolf. DNA studies have shown that 95 per cent of the dogs in the world are descended from the same three females. This is probably because those ancestral dogs showed a special trait that made them much more useful to humans. Dogs are better than any other animal at correctly recognising and interpreting human social cues; better even than our closest relative the chimpanzee, and far better than a wolf. This is true even with puppies as young as nine weeks, which shows this is an innate ability rather than something learned from close association.

Originally, dogs were kept exclusively for their hunting and defensive value but about 12,000 years ago, a mutation emerged that resulted in miniature dog breeds. Later, breeders began selecting for 'cute' features to create dogs that keep puppy characteristics into adulthood, such as floppy ears and rounder faces. At the same time, much of the pack instinct of many dog breeds was lost. Dogs became pets, rather than just weapons.

Dogs show more physical variation between breeds than any other domesticated animal. Genetically, the Tibetan Lhasa Apso and the Chinese Shih Tzu are closest to the ancestral dog but the earliest dogs would have been sight hounds, like the wolf. These are dogs that track their prey visually and rely on short bursts of speed to bring them down. They have long thin heads and long legs. Later, scent hounds emerged with shorter faces and short legs to keep their nose close to the ground. These dogs hunt game over much larger distances by following a scent trail and they use their superior endurance to exhaust an animal.

The bulldog has come to epitomise British spirit



Canine comparison

Despite vast differences in size all dogs share the same anatomical traits and history.

Head to Head DOG BREEDS

BIGGEST

1. Mastiff

While Irish wolfhounds may be taller, the Mastiff is the heaviest dog breed weighing as much as 155kg, or 24st 5lb. That's more than a fully grown man!

SMALLEST

2. Chihuahua

At just 15-23cm from nose to the tip of the tail, the Chihuahua is the smallest breed. It's because of their size that sadly they have become a popular Hollywood accessory.

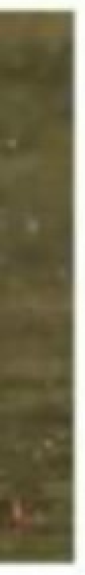
LOUDEST

3. German Shepherd

Sentry breeds like the German Shepherd have very loud barks. The record is 108 decibels by a German Shepherd called Daz.

DID YOU KNOW? Chocolate, onions, grapes and macadamia nuts can all be poisonous for dogs to digest

Dogs can perform a number of tasks to aid humans



Clever dog!

Just how bright are our four-legged friends?

The average domestic dog can exhibit social intelligence that's seldom found in the animal world, even in our closest relative the chimp. Dogs can learn, and therefore be trained, in a number of ways by reinforcement (punishment and reward) and by observation. For instance, puppies will learn behaviour more quickly if they follow the examples set by older dogs and will even learn from watching humans perform tasks.

Dogs can demonstrate a sophisticated social cognition by associating behavioural cues with an abstract meaning. In tests dogs have successfully located a treat hidden under one of two buckets from a wide range of signals including taps, nods and even looks. In fact they out-performed chimpanzees, wolves and human infants at the task.

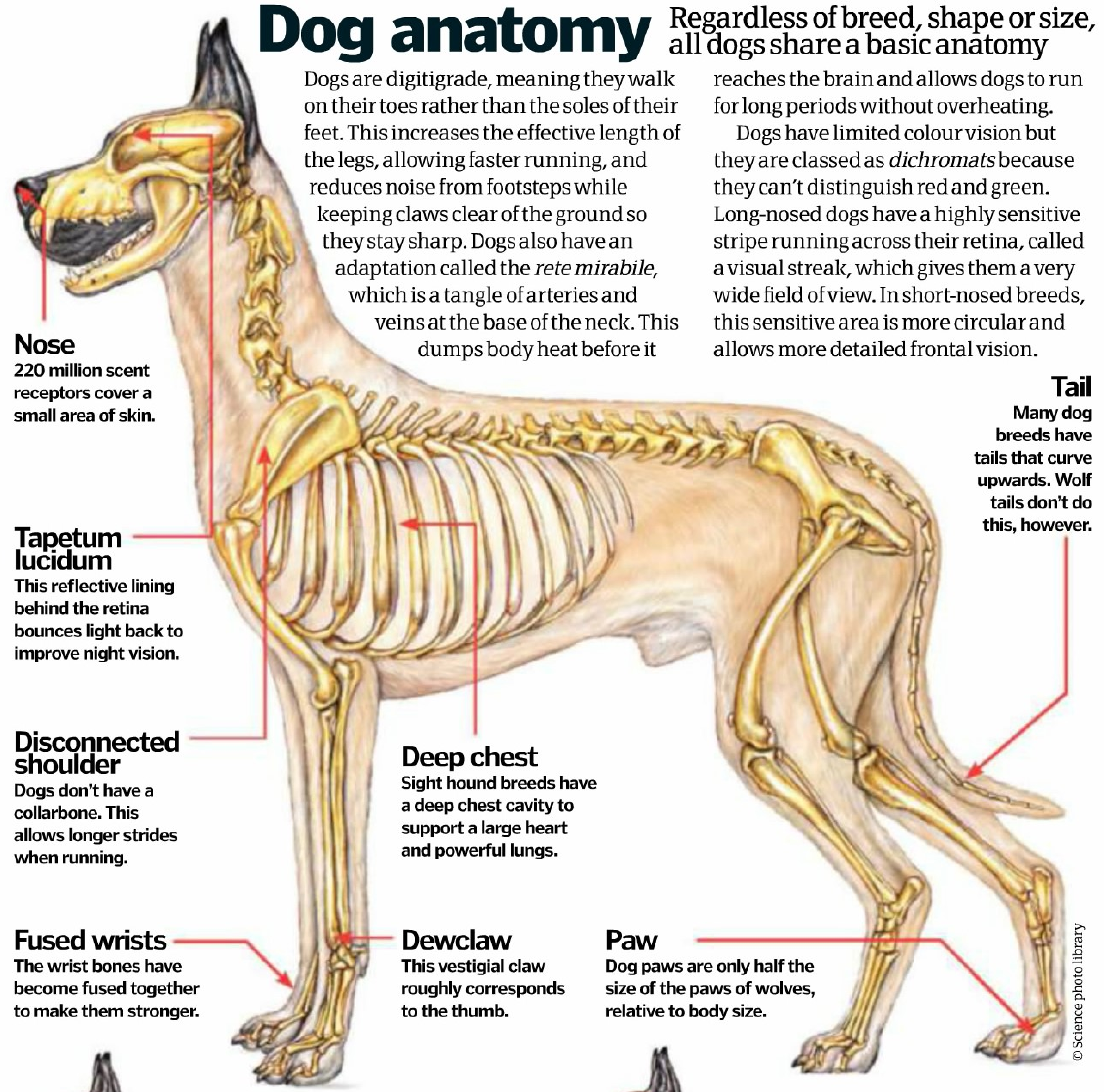
The new remake of *The Usual Suspects* wasn't quite as successful as hoped…

Dog anatomy

Regardless of breed, shape or size, all dogs share a basic anatomy

Dogs are digitigrade, meaning they walk on their toes rather than the soles of their feet. This increases the effective length of the legs, allowing faster running, and reduces noise from footsteps while keeping claws clear of the ground so they stay sharp. Dogs also have an adaptation called the *rete mirabile*, which is a tangle of arteries and veins at the base of the neck. This dumps body heat before it reaches the brain and allows dogs to run for long periods without overheating.

Dogs have limited colour vision but they are classed as *dichromats* because they can't distinguish red and green. Long-nosed dogs have a highly sensitive stripe running across their retina, called a visual streak, which gives them a very wide field of view. In short-nosed breeds, this sensitive area is more circular and allows more detailed frontal vision.



Nose
220 million scent receptors cover a small area of skin.

Tapetum lucidum
This reflective lining behind the retina bounces light back to improve night vision.

Disconnected shoulder
Dogs don't have a collarbone. This allows longer strides when running.

Fused wrists
The wrist bones have become fused together to make them stronger.

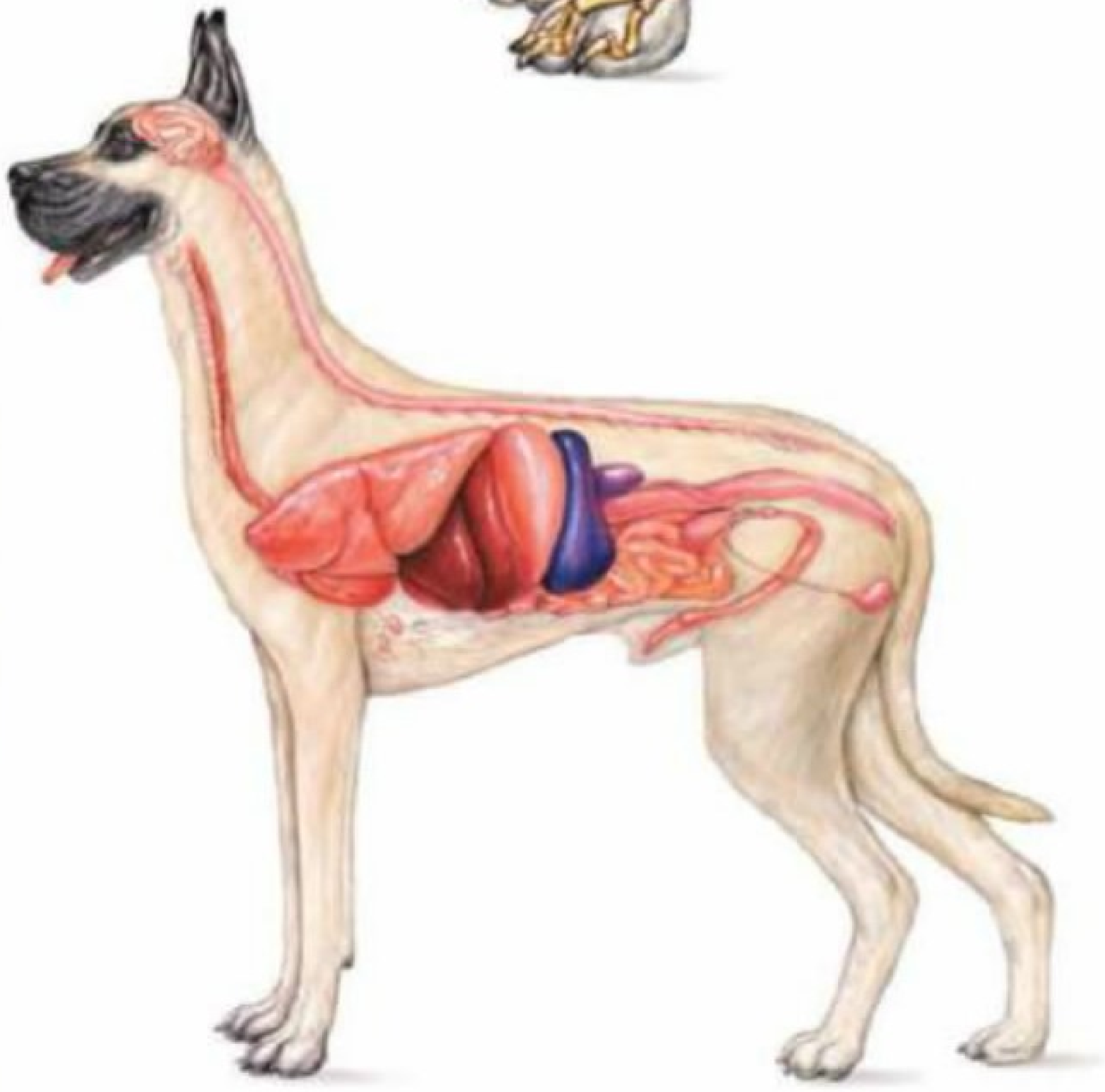
Deep chest
Sight hound breeds have a deep chest cavity to support a large heart and powerful lungs.

Dewclaw
This vestigial claw roughly corresponds to the thumb.

Paw
Dog paws are only half the size of the paws of wolves, relative to body size.

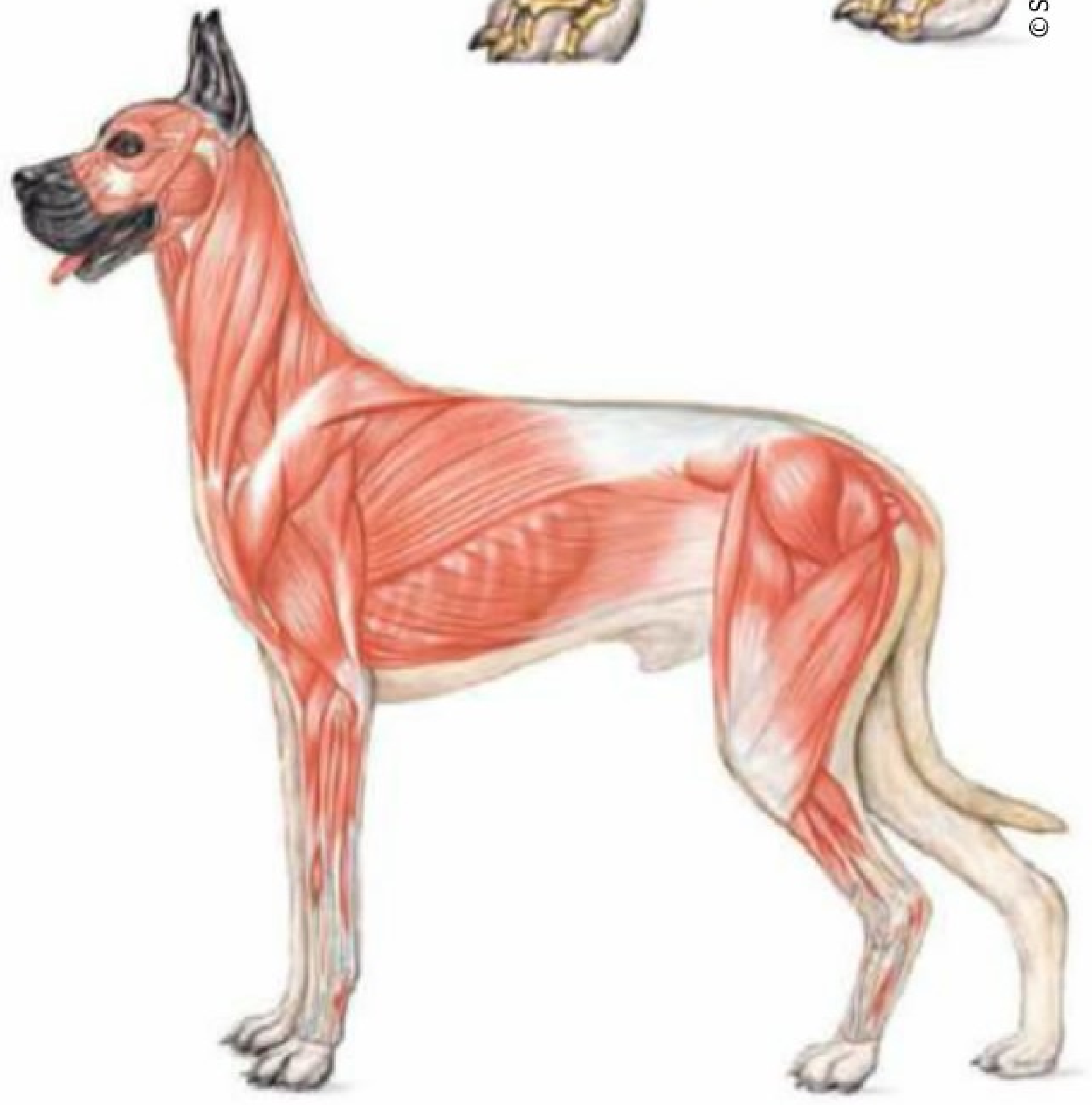
Tail
Many dog breeds have tails that curve upwards. Wolf tails don't do this, however.

© Science photo library



Internal organs

Unlike the cat family, dogs are not compulsory carnivores. Their intestine is long enough to digest a wide range of vegetables and grains and plant proteins can make up a large part of a healthy diet. Some human foods are quite toxic to dogs though, including chocolate and grapes.



Muscular system

Dogs have 18 separate muscles that are used to raise, tilt and rotate the ears. As well as being used to communicate with humans and other dogs, steerable ears allow a dog to accurately identify where a sound is coming from quicker and hear sounds four times further away than we can.

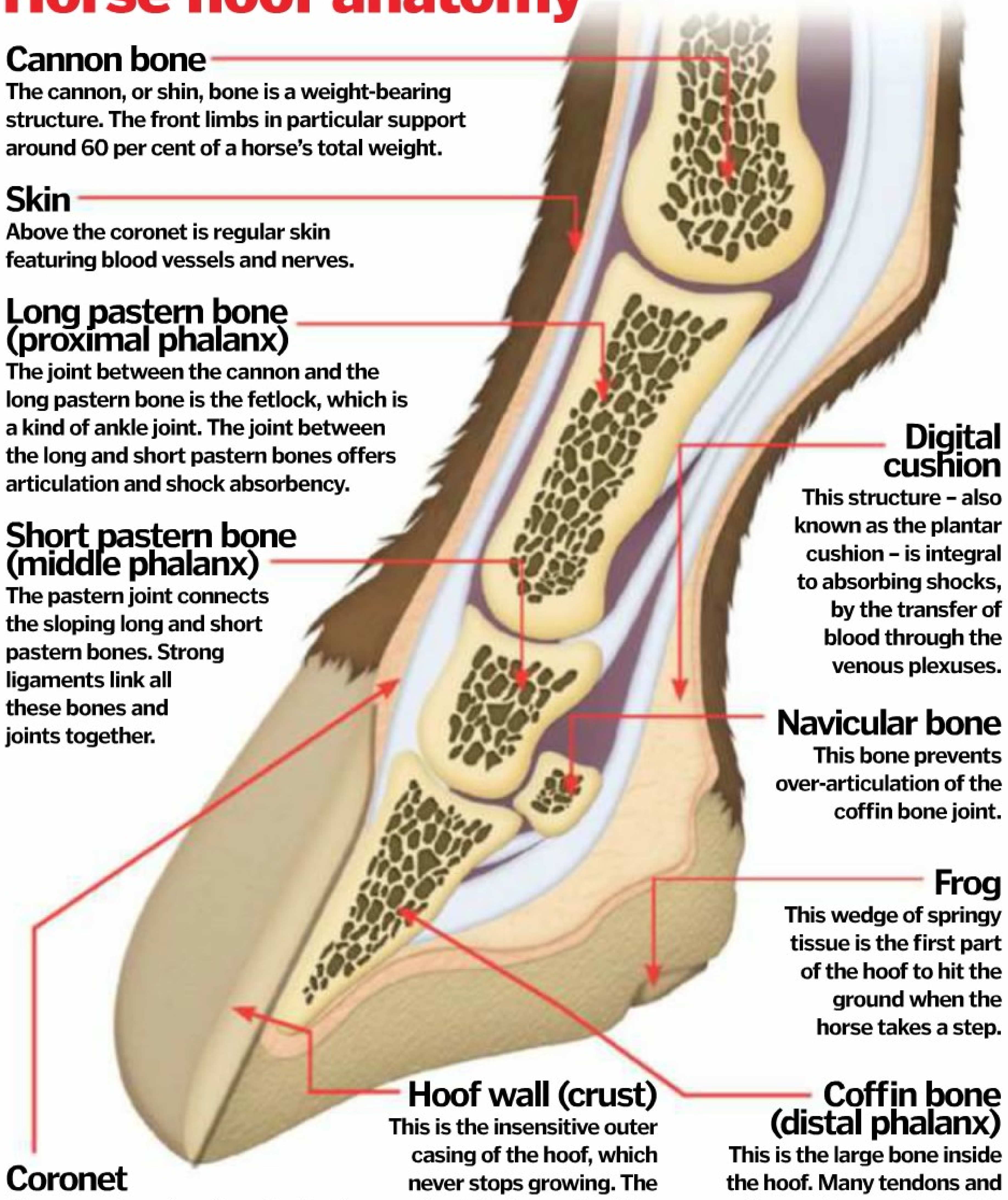
What's inside horse hooves?

Discover the structure of a horse's feet and why fitting horseshoes doesn't cause pain

Horse hooves are the thick horny coverings that protect the end of the horse's leg and also provide shock absorbency. Horse hooves are made of a tough protein called keratin – the same stuff our nails and hair are made of. The keratin in a horse's hoof is layered in horizontal sheets, in order to add strength and minimise the extent of any damage that could split the hoof irreparably in the event of a crack.

Horses are digitigrade – ie they walk on their tiptoes – and therefore require a spongy pad beneath the heel on which to walk. While the outer wall of the hoof is insensitive – much like human hair and fingernails – the inner parts can feel pain. Therefore, when a farrier fits a horseshoe to the hoof, they do so by hammering the nails into only the outer wall of the hoof. Horseshoes, which are often made of steel these days, offer added shock absorbency as well as traction on the ground. These curved metal bands come with between six and eight square nail holes through which the metal pins can be slotted. One by one, the nails are hammered into the hard, nerve-free outer wall of the hoof, securely fastening the shoe to the creature's hoof.

Horse hoof anatomy



Cannon bone
The cannon, or shin, bone is a weight-bearing structure. The front limbs in particular support around 60 per cent of a horse's total weight.

Skin
Above the coronet is regular skin featuring blood vessels and nerves.

Long pastern bone (proximal phalanx)
The joint between the cannon and the long pastern bone is the fetlock, which is a kind of ankle joint. The joint between the long and short pastern bones offers articulation and shock absorbency.

Short pastern bone (middle phalanx)
The pastern joint connects the sloping long and short pastern bones. Strong ligaments link all these bones and joints together.

Digital cushion
This structure – also known as the plantar cushion – is integral to absorbing shocks, by the transfer of blood through the venous plexuses.

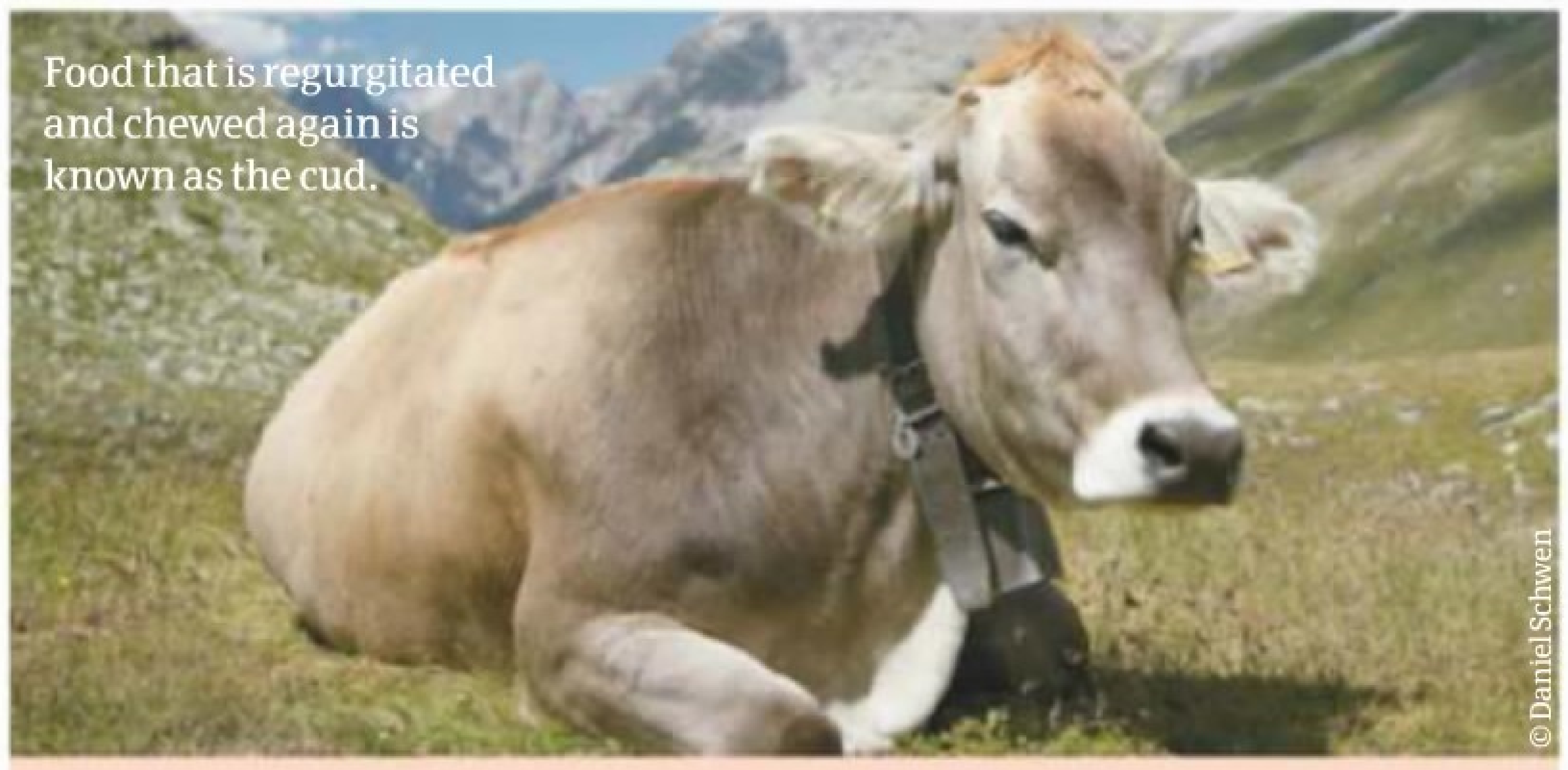
Navicular bone
This bone prevents over-articulation of the coffin bone joint.

Frog
This wedge of springy tissue is the first part of the hoof to hit the ground when the horse takes a step.

Coronet
The coronet marks where the hoof meets the leg. The wall of the hoof grows out of this small bulge.

Hoof wall (crust)
This is the insensitive outer casing of the hoof, which never stops growing. The front-facing walls of the fore-hooves are slightly thicker than the rest.

Coffin bone (distal phalanx)
This is the large bone inside the hoof. Many tendons and ligaments are attached to this and a network of blood vessels run through it.



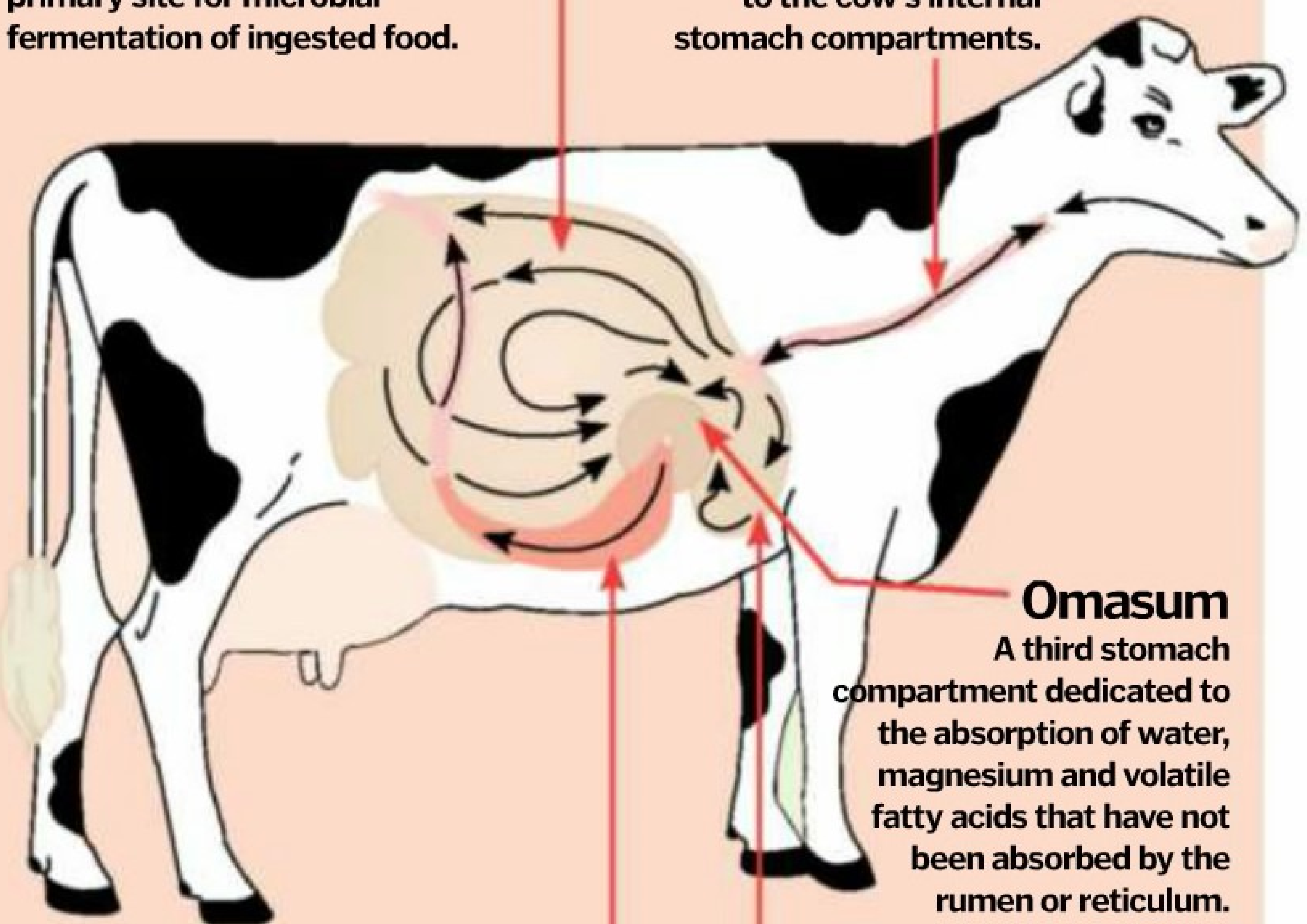
Food that is regurgitated and chewed again is known as the cud.

© Daniel Schwen

How does a cow's stomach work?

A complex system of sacs and guts, cows' stomachs allow seemingly indigestible foods to be broken down

A cow's stomach is a compartmental digestive system that allows normally indigestible products (grasses, for example) to be broken down repeatedly in a process of ingestion, regurgitation, rechewing and reingestion. Through this process cows can decompose the ingested product's carbohydrates, cellulose and volatile fatty acids and use them as fuel. Decomposition and breakdown is achieved by a series of bacteria and protozoa living, multiplying and dying inside the stomach's compartments. These microbes digest fibre found in pasture, hay and silage, generate proteins from nitrogen and synthesise amino acids from non-protein sources such as urea and ammonia. The microbes grant the cow additional energy, as when they die they continue to pass through the digestive compartments, breaking down and releasing protein.



Rumen
Consisting of several muscular sacs, the rumen is the first and primary site for microbial fermentation of ingested food.

Oesophagus
The ingestion canal that transports consumed food to the cow's internal stomach compartments.

Omasum
A third stomach compartment dedicated to the absorption of water, magnesium and volatile fatty acids that have not been absorbed by the rumen or reticulum.

Abomasum
The 'true' stomach compartment of the cow, the abomasum functions similar to that of humans', with secreted enzymes and hydrochloric acid breaking down proteins.

Reticulum
The second main site for microbial fermentation, this makes up the smaller partner of the rumen.

Badger setts

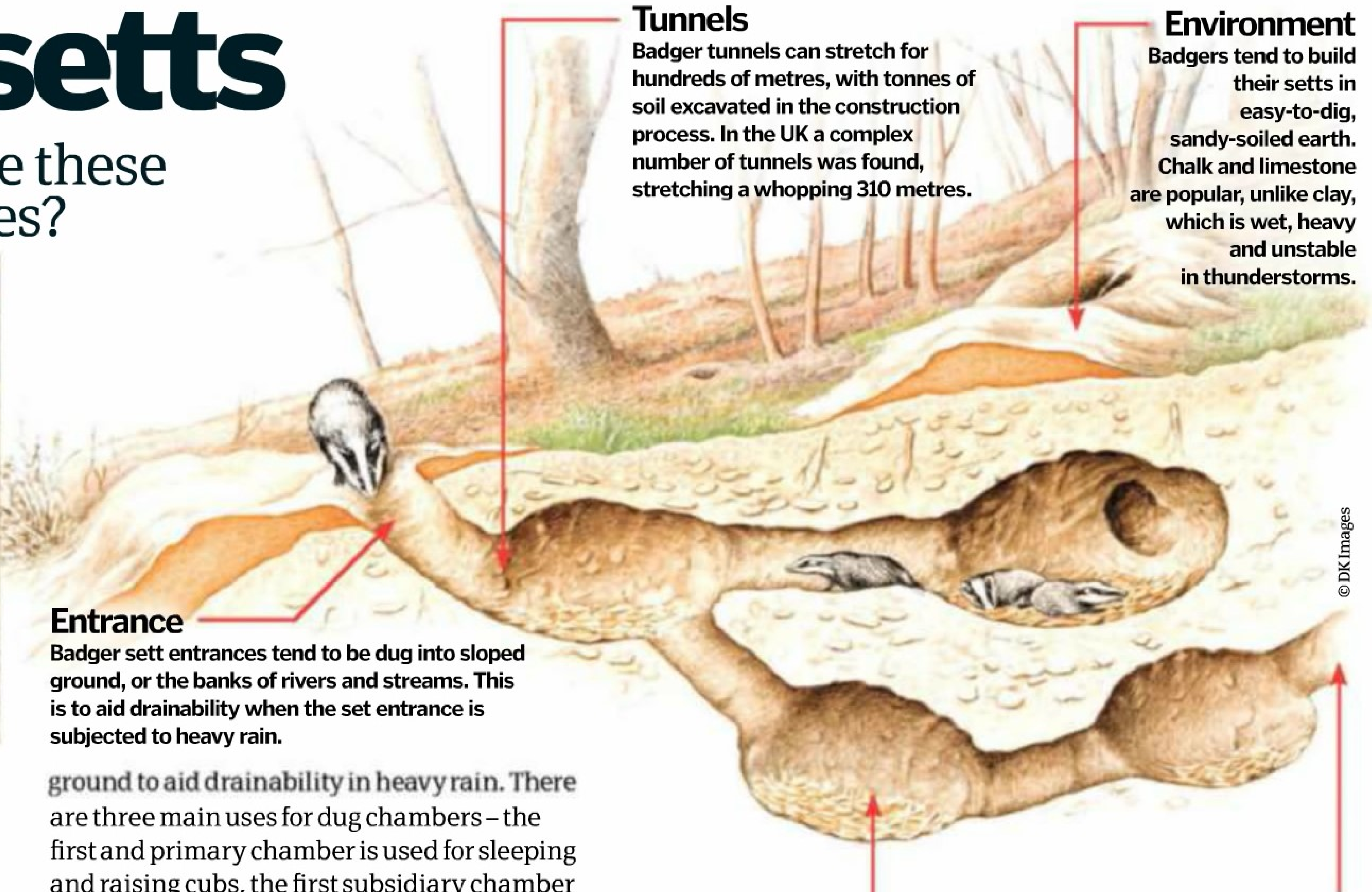
Why do badgers create these labyrinthine structures?

The badger doesn't just settle for a simple hole

© BadgerHero

Badgers dwell in a series of underground tunnels and chambers, referred to as a 'sett'. These setts tend to be built over multiple levels (which aids air flow) and interlinked with other tunnels stretching hundreds of metres. Setts tend to be dug in woodland areas that are free of vegetation, and in sandy, easy-to-dig soils. Each sett can have multiple entrances, however each one tends to be formed in earth banks on sloped ground to aid drainability in heavy rain. There are three main uses for dug chambers – the first and primary chamber is used for sleeping and raising cubs, the first subsidiary chamber is used for mating and the second subsidiary chamber is used for defecation.

Interestingly, badger setts are also often commandeered by other animals, due to their size and build quality. Such inhabitants include foxes – often to raise young – rabbits and ferrets.



Tunnels
Badger tunnels can stretch for hundreds of metres, with tonnes of soil excavated in the construction process. In the UK a complex number of tunnels was found, stretching a whopping 310 metres.

Environment
Badgers tend to build their setts in easy-to-dig, sandy-soiled earth. Chalk and limestone are popular, unlike clay, which is wet, heavy and unstable in thunderstorms.

© DK Images

Entrance
Badger sett entrances tend to be dug into sloped ground, or the banks of rivers and streams. This is to aid drainability when the set entrance is subjected to heavy rain.

Chambers
Setts consist of multiple chambers, which are spaced out and used for a variety of purposes. The primary chamber is for sleeping while subsidiary chambers are used for breeding and defecation.

Links
Due to their secretive natures – often only coming to the surface at night – badgers tend to interlink their setts and tunnels with others to aid movement and predator avoidance.

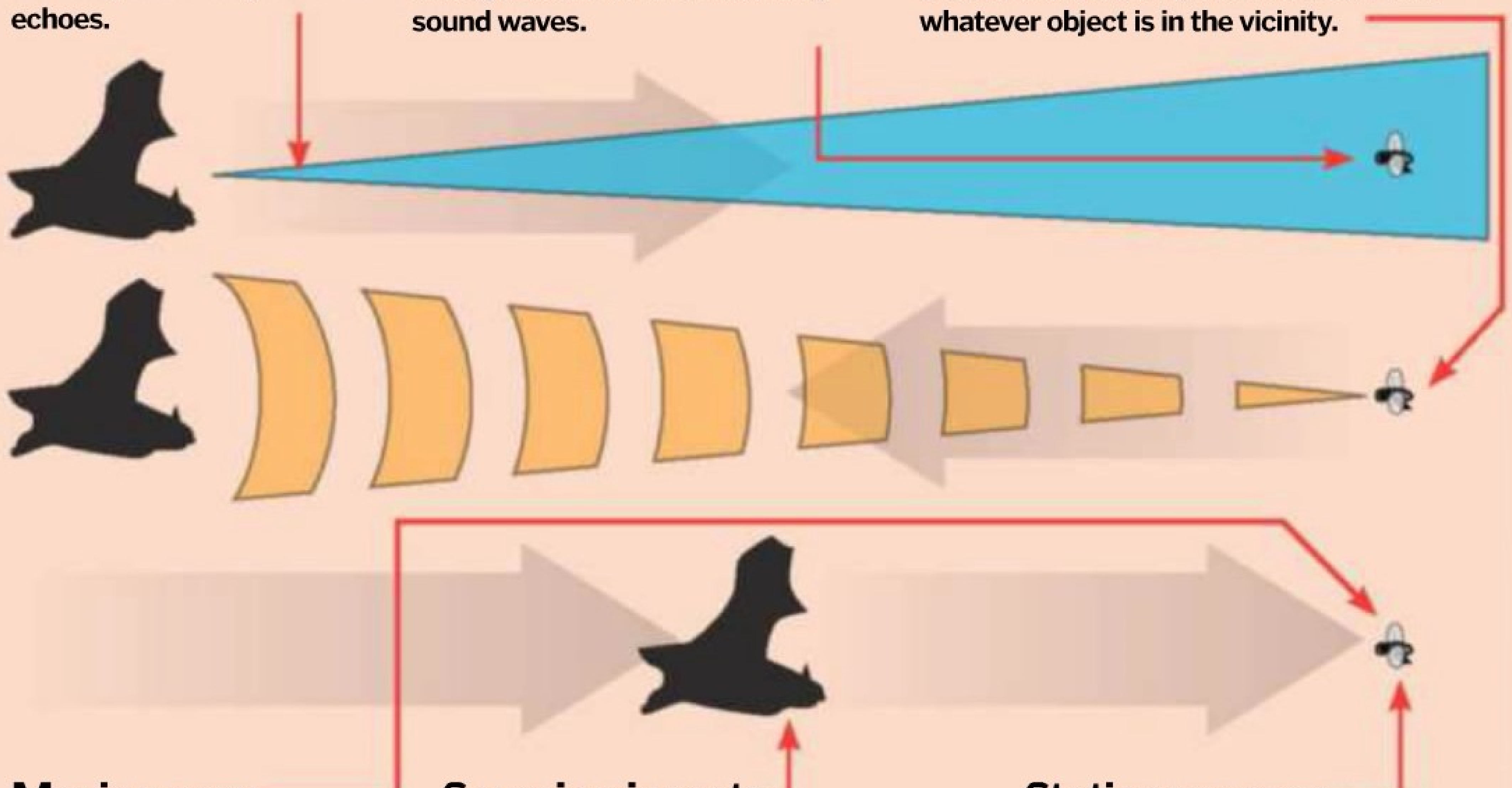
Bats' ultrasonic sonar system

We reveal how Chiroptera's supersonic hearing happens

Contrary to belief, bats (Chiroptera) do demonstrate an acute sense of vision, however this is shown during daylight conditions. When night falls, these small mammals are more inclined to use their heightened sense of hearing when hunting prey and manoeuvring around habitats, never being at a disadvantage. This is complemented by their incredible biological sonar navigation system.

But how does this work? Well, bats are inclined to emit ultrasonic sounds, with a frequency of between 50,000 and 200,000 vibrations per second, too high-pitched for human ears to comprehend.

These sound are emitted 20 to 30 times each second in all directions, with the bat listening between pulses, scanning for echoes with its head in perpetual motion. Bats separately perceive and process overlapping echo delays, arriving as little as two microseconds apart, that's an impressive two thousandths of a second. The bat's own nervous system supports this fined-tuned capability, allowing Chiroptera to identify echo-reflecting points on an object the width of a pen line on paper, or objects as close together as three-tenths of a millimetre.



Emitting sound
Bats emit ultrasonic sounds 20 to 30 times each second, listening between pulses for echoes.

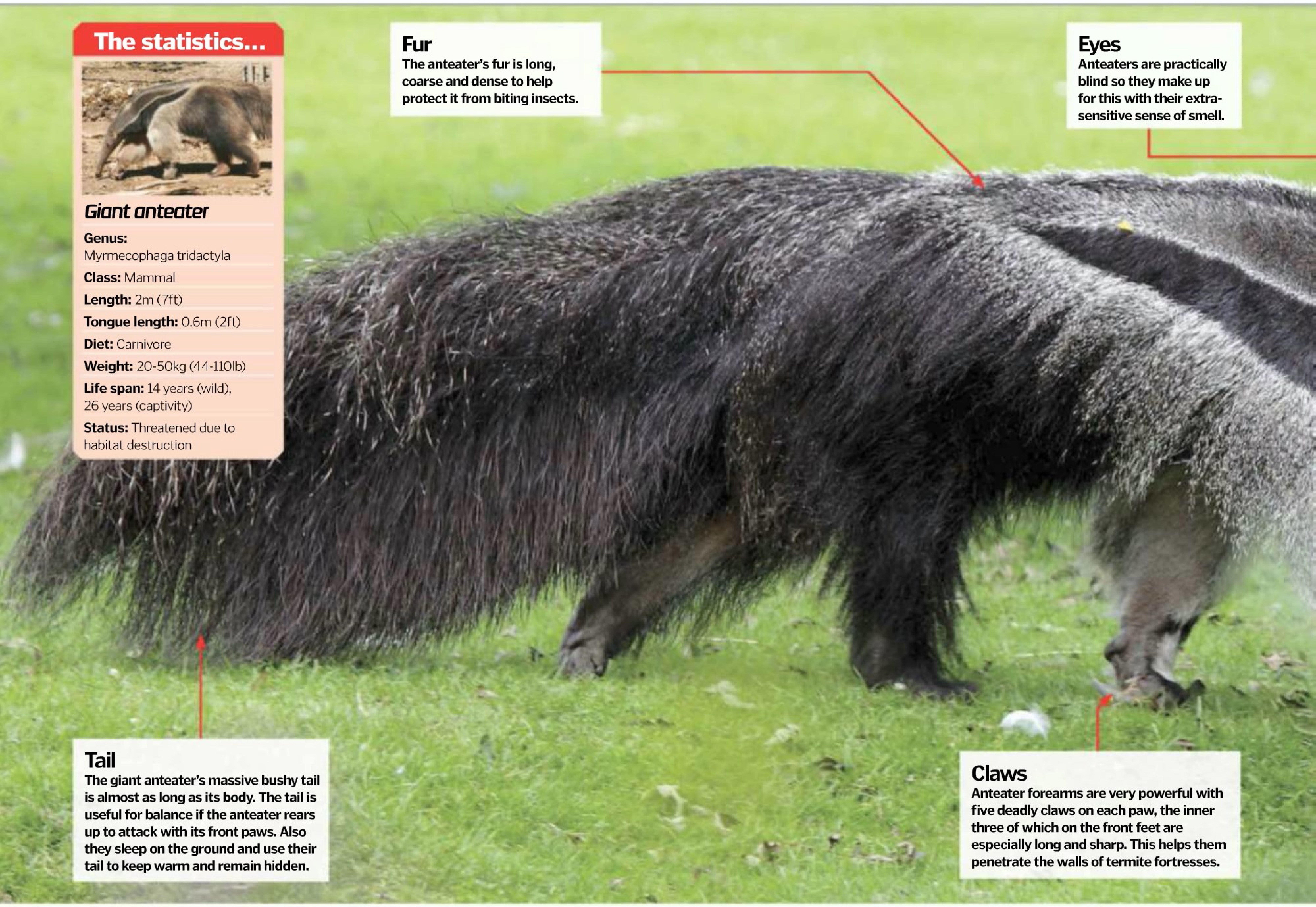
Timing and direction
The bat then registers distance and location of prey through the timing and direction of returning sound waves.

Translating echo
The time between sending out a cry and then receiving a response is translated by the bat into distance, between itself and whatever object is in the vicinity.

Moving prey
The bat realises moving prey through delayed sound and a slightly lower or higher pitch, due to the Doppler effect.

Sourcing insects
Echoes from prey such as mosquitoes, moths and butterflies reveal fluctuations, which are caused by the flutter of their wings, easily recognised by the bat.

Stationary prey
Stationary objects are instantly recognisable, as these yield an echo that is a replica of the pulse sent out by the bat.



The statistics...

Giant anteater

Genus: Myrmecophaga tridactyla
Class: Mammal
Length: 2m (7ft)
Tongue length: 0.6m (2ft)
Diet: Carnivore
Weight: 20-50kg (44-110lb)
Life span: 14 years (wild), 26 years (captivity)
Status: Threatened due to habitat destruction

Fur
The anteater's fur is long, coarse and dense to help protect it from biting insects.

Eyes
Anteaters are practically blind so they make up for this with their extra-sensitive sense of smell.

Tail
The giant anteater's massive bushy tail is almost as long as its body. The tail is useful for balance if the anteater rears up to attack with its front paws. Also they sleep on the ground and use their tail to keep warm and remain hidden.

Claws
Anteater forearms are very powerful with five deadly claws on each paw, the inner three of which on the front feet are especially long and sharp. This helps them penetrate the walls of termite fortresses.

Giant anteaters

They have no teeth, walk on their knuckles and take life at their own pace, so how do they survive?

As is to be expected, the giant anteater, native to the savannas of Central and South America, is the largest of its kind. This bizarre-looking mammal is designed specifically for feeding on ants and termites, and a number of anatomical features enable them to do this with great skill. Powerful forearms and long, sharp claws help the anteater to tear into anthills and termite mounds so they can insert their long, tapered snouts to get at the insects. They are always careful not to destroy the nest so as to preserve the feeding spot for another meal.

While the claws are mainly used for breaking into anthills, they can also perform a defensive role. When attacked by their main predators, which include large cats like jaguars, anteaters have been known to lash out and kill these hunters. While giant anteaters are slow, terrestrial creatures that walk around on their knuckles to protect the claws, smaller species of anteater are arboreal and spend a lot of time in trees looking for insects.

The giant anteater is a solitary creature and, aside from mothers and babies, they are rarely found in pairs or groups. Anteaters usually give birth to a single cub, who will then ride around on the mother's back for up to a year, clinging on to the thick, coarse fur. Because they live on a diet of ants, which have relatively limited nutritional value, the giant anteater does what it can to conserve energy: it has a very low metabolic rate and will sleep for up to 15 hours every day. They move around the grasslands very slowly – they cannot run – and keep their body temperature low, sometimes as cool as 32.7 degrees Celsius (90.9 degrees Fahrenheit).

An anteater's sense of smell is so acute it can detect the species of ant or termite before breaking into a nest

HEAD to Head
XENARTHRA

1. SUPER-SLOW

Sloth
This nocturnal rainforest dweller hangs in trees by its large, powerful claws, eating vegetation. They move very slowly, and can spend a year in one tree.

2. ARMOURED

© www.birdphotos.com

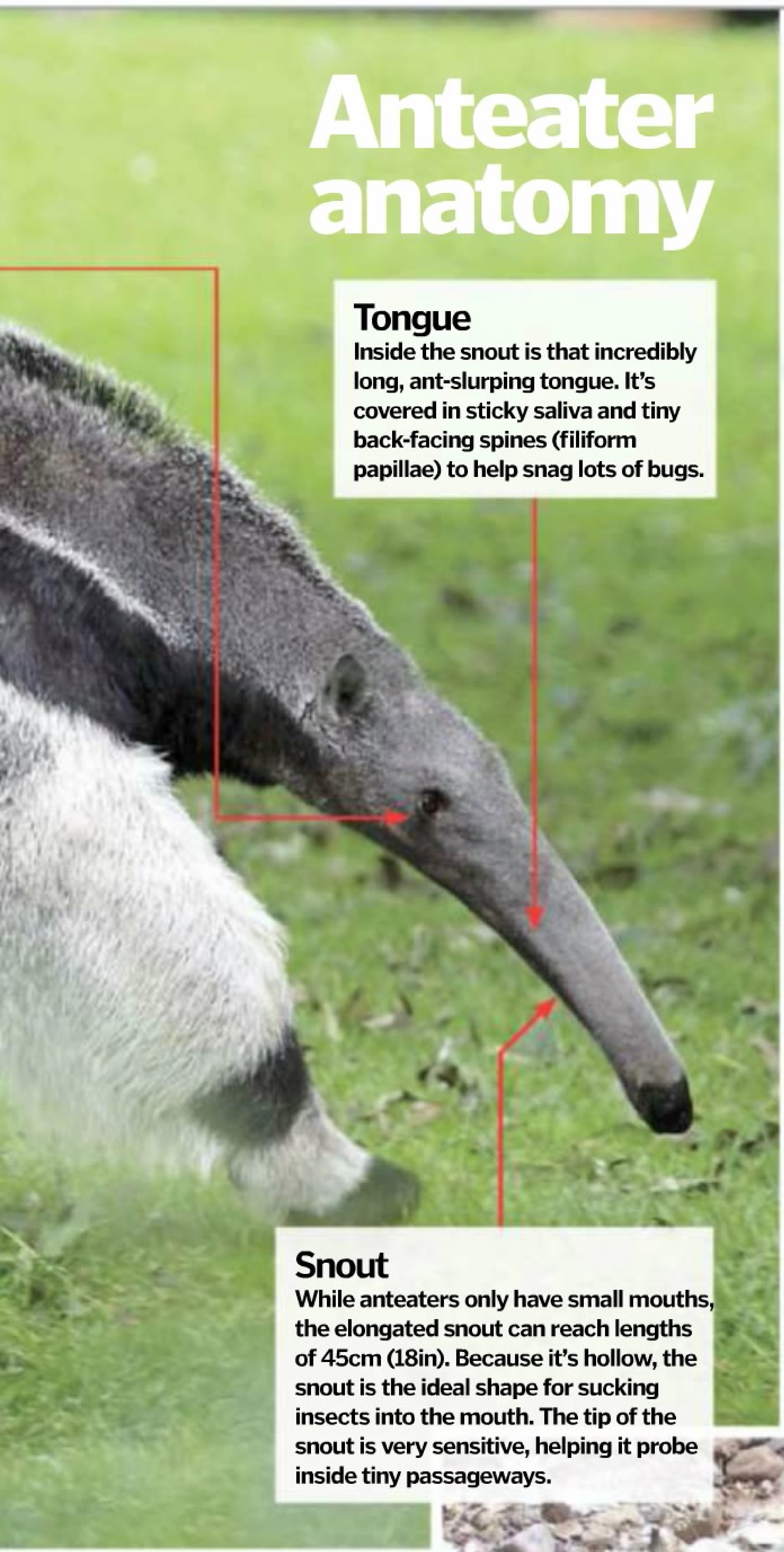
Armadillo
Another insectivore, the armadillo has hard, leathery plates on its back, head and sides. It also has the ability to hold its breath for several minutes when digging.

3. EDENTATE

Anteater
Anteaters, sloths and armadillos are all members of the xenarthra superorder. In the past, they were grouped as the edentata – meaning toothless – but only the anteater is actually toothless.

DID YOU KNOW? Surrealist artist Salvador Dalí had a pet anteater which he used to take for walks

Anteater anatomy



Tongue
Inside the snout is that incredibly long, ant-slurping tongue. It's covered in sticky saliva and tiny back-facing spines (filiform papillae) to help snag lots of bugs.

Snout
While anteaters only have small mouths, the elongated snout can reach lengths of 45cm (18in). Because it's hollow, the snout is the ideal shape for sucking insects into the mouth. The tip of the snout is very sensitive, helping it probe inside tiny passageways.

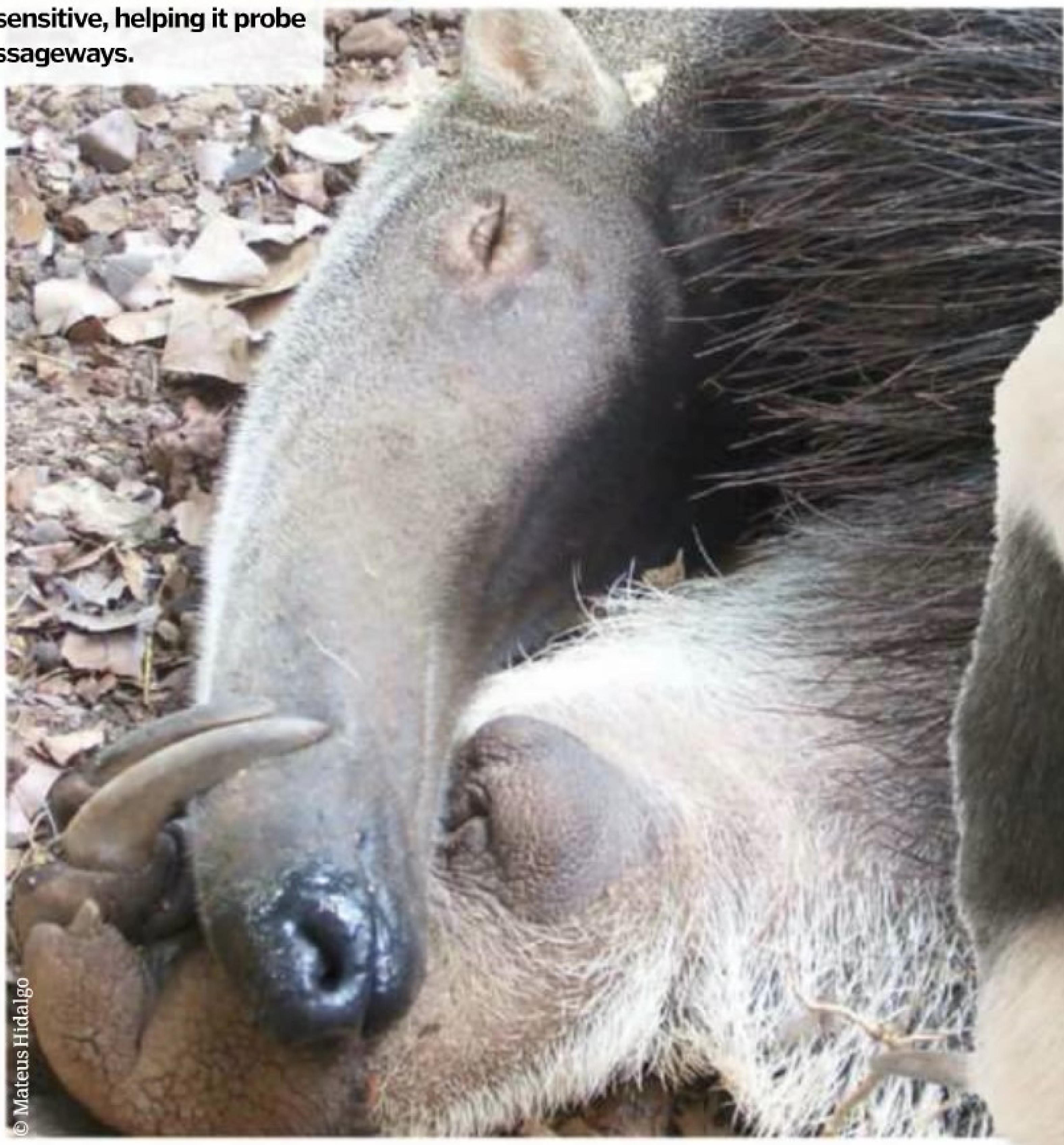
Eating ants

Although they have poor eyesight, anteaters have a very keen sense of smell for sniffing out insects, which include ants – of course, termites, grubs and other small insects.

Once an anthill is located the animal uses its strong claws to rip into the prey's lair, making room to insert its long snout. Because some ants can sting and bite, mealtime is a fast and furious affair and the anteater has adapted techniques for licking up ants as quickly as possible. Each feast lasts about a minute before the anteater moves on to the next location.

Inside the anteater's long snout is an even longer tongue, which can protrude up to 60cm (24in). The tongue is covered with sticky saliva produced by extra-large glands and thousands of tiny back-facing spines known as filiform papillae to ensnare the bugs. When the snout enters an anthill the tongue rapidly flicks back and forth up to 150 times per minute, searching for ants. Because it doesn't have teeth, the anteater then crushes the insects against the roof of its mouth with its powerful tongue before swallowing.

Every day an anteater can consume between 30,000 and 35,000 ants, which is necessary for them to obtain enough nutrients. While ants may contain relatively high levels of protein and low levels of fat, their nutritional value for the giant anteater is low, so in order to conserve energy they move slowly and maintain a cool body temperature.


© Mateus Hidalgo

Giant anteaters can sleep for up to 15 hours a day

Meet the family

While the giant anteater is terrestrial, other types are known to venture into the treetops

© Michelle Reback

SILKY ANTEATER
Also known as pygmy, dwarf or two-toed anteaters, silky anteaters are the smallest and most shy species in the family. They are arboreal, which means they spend most of their time up in the trees – in fact, they're rarely ever seen on the ground. To help them get around in the treetops they have strong prehensile tails that can grip on to things; they use them to swing from branch to branch and even from tree to tree. They have much shorter snouts than the other species and soft golden fur.

Tamanduas live from southern Mexico down to northern Argentina

TAMANDUA
Tamanduas are sometimes known by other names, such as collared or lesser anteaters. This species is semi-arboreal, which means they spend time up in the trees but also come down for a look around on the ground now and then. Again, when in the trees a prehensile tail comes in very handy. There are northern and southern tamanduas; the former variety is distinguishable not only by its more northerly location, but also because of the distinctive black V-shaped marking that's located on its back.

Wolves

They may be the ancestors of man's best friend but these social carnivores are totally equipped for life in the wild

Wolves evolved around 2 million years ago, at the end of the Pliocene epoch. There are 37 subspecies of canis lupus but that includes two that aren't actually wolves. That's because about 16,000 years ago wild wolves were domesticated by man and eventually became canis lupus familiaris, or the dog. In Australia, some dogs escaped to form a feral subspecies – the dingo.

The modern wolf isn't just an undomesticated dog, however. For thousands of years, domestication has acted to change the genetics of the wolf, as well as the dog. Early humans tamed the friendliest and most empathic members of the wild wolf population, so the ones that were left behind were the more suspicious and reclusive individuals. Later, when wolves were hunted because of the threat they posed to humans and livestock, wolves were pushed to ever more remote and forbidding environments and they grew tougher as a result.

Wolf subspecies are divided into the Northern and Southern wolves. The Southern wolves live in the Middle East and South Asia and are lighter than their cousins, with smaller brains, weaker jaws and shorter fur. The Northern wolves, on the other hand, are adapted to survive in cold climates and live primarily in North America and northern Russia. The largest subspecies is the grey wolf (canis lupus lupus).

Most of the early studies of wolf social structure were based on captive animals and packs in national parks with artificially abundant food supplies. This led researchers to believe that wolves lived in large packs of 15-30 animals, with an alpha male in charge. The alpha male had priority access to the breeding females and led the hunt. Younger males would either try and sneak food and mating opportunities without the alpha male noticing or would gradually work their way up the ranks until they were strong enough to challenge the alpha for the top job. We now know that wolves form much smaller packs in the wild, consisting of close family members and generally hunt in groups of just two to six. This is an adaptation to the harsh conditions in which they live because larger packs actually catch less food per individual than the smaller ones.

Wolves are opportunistic hunters and will eat a wide range of animals from mice and birds to hares and deer. But when they go after these small and medium-sized prey, they are competing with a lot of other predators, including eagles, lynx and wolverines. Where wolves excel is in hunting the

5 TOP FACTS BORN SURVIVORS

Nothing wasted
1 Wolves will eat virtually every part of an animal but they start with the liver, heart and lungs. Then they move on to the muscles, followed by the skin and bone marrow.

Outrunner
2 Wolves can sustain speeds of 40km/h (25mph) for 20 minutes and sprint at up to 61km/h (38mph). One wolf is known to have chased a deer for 21 kilometres (13 miles).

Dry fur
3 Wolf fur does not collect condensation if you breathe on it. This trait means that in cold weather frost is prevented from forming around the muzzle.

Frost resistant
4 Arctic wolves can sleep outside quite comfortably in temperatures as low as -40°C (-40°F). They tuck their muzzles between their rear legs and wrap their tails over their faces.

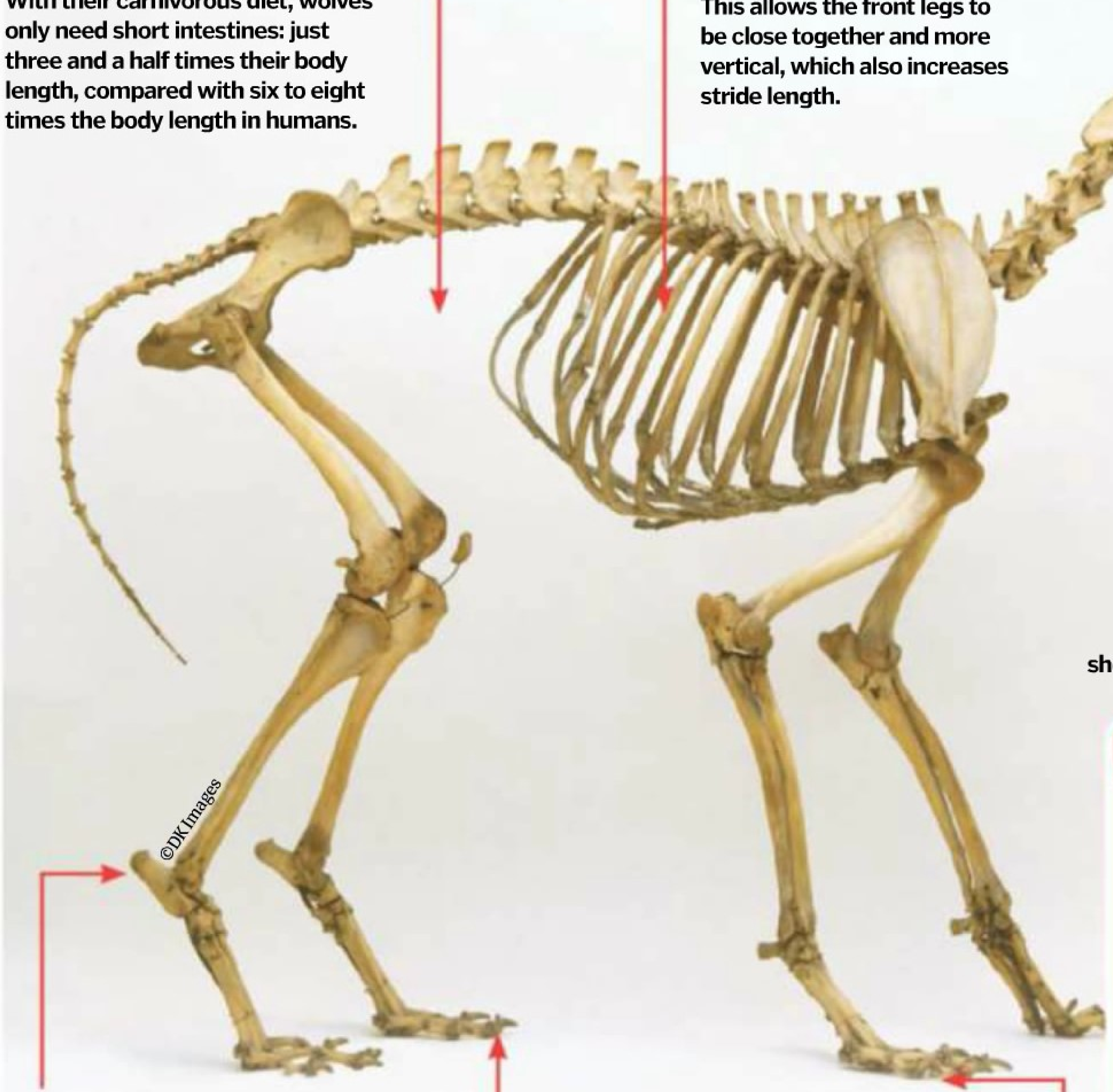
Lifting power
5 An adult wolf is strong enough to roll a frozen horse or moose by itself. This enables it to get at the underside of the carcass, which may not be frozen solid yet.

DID YOU KNOW? *A wolf's stomach can hold 9kg (20lbs) of food. That's the equivalent of 42 Big Macs!*

Snarling is common but is more likely to deter fighting than lead to it

©Science Photo Library

Wolf anatomy



©DK Images

Intestine
With their carnivorous diet, wolves only need short intestines: just three and a half times their body length, compared with six to eight times the body length in humans.

Deep ribcage
This allows the front legs to be close together and more vertical, which also increases stride length.

Eyesight
Wolves have worse daytime vision than domestic dogs but the best night vision of any of the dog family.

Smell
Not as sensitive as the nose of a hunting dog because wolves mainly locate prey by sound and following tracks.

Teeth
There are long canines at the front to grip and kill, while the carnassials at the back act like shears to slice meat from the bone.

Achilles' heel
The heel extends out a long way to provide extra leverage for the calcaneal, or Achilles', tendon.

Tippy toes
Wolves are digitigrade, which means they walk on tip-toes. The rest of the foot extends the effective length of the leg and allows longer strides.

Footpads
The temperature of the footpad is regulated independently to keep it only just above tissue freezing point and conserve body heat.

The statistics...

Grey wolf

Type: Mammal

Diet: Carnivore

Average life span in the wild: 8-12 years

Weight: 38kg (84lb)

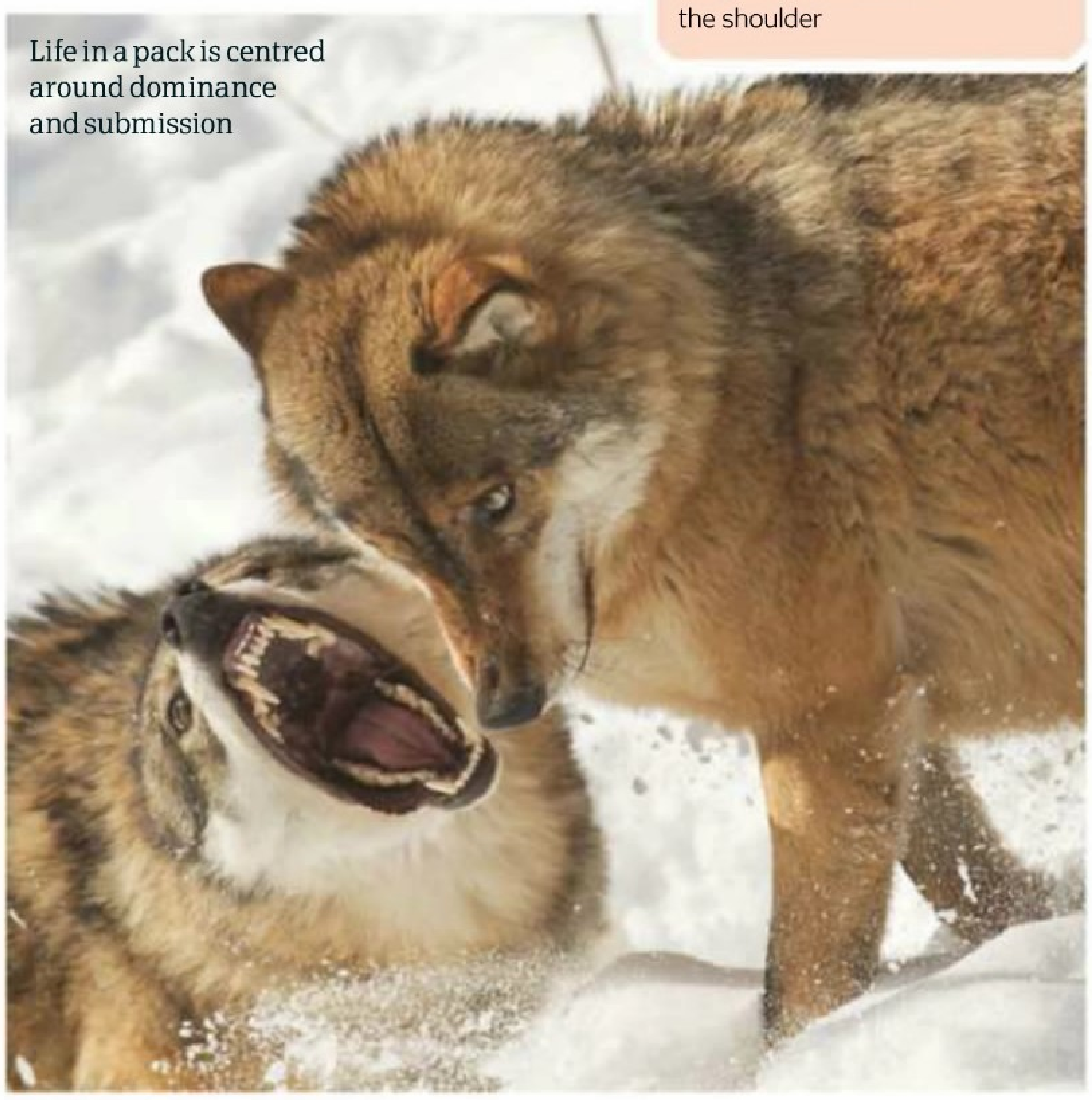
Height: 85cm (33in) at the shoulder

huge elk, bison and caribou. These animals may weigh 10 or 15 times as much as an individual wolf and have horns and a powerful kick to defend themselves. Hunting this kind of quarry is all about escaping injury. The elk is fighting for its life and can afford to put everything it has into the struggle; the wolf, however, is only fighting for its dinner so must be more careful. One well-aimed kick may injure him badly enough that he can't hunt and will starve to death before his wounds heal.

A pack can travel 19-80 kilometres (12-50 miles) in a day, looking for a herd. When they find one, they don't waste time stalking. Instead they will trot straight up and weave in and out among the herd, trying to spook it into running. A herd of elk or caribou is almost impregnable if it stands its ground but once it starts running, the wolves can run alongside and weigh up which are the weakest individuals. Wolves have no problem keeping up and can bound through deep snow more easily than narrow-hoofed deer. When they pounce, they will strike for the soft tissue of the perineum; their teeth can leave a 15-centimetre (5.9-inch) wound that results in massive blood loss. Three bites can be enough to bring down a healthy adult elk. Another tactic is to jump for the nose – also a soft area that bleeds profusely.

Despite all this, only about one attack in ten results in a kill. And when they are successful, the wolves still have to defend the carcass from various other predators such as bears, coyotes, wolverines and other wolves. Large grizzly bears will often follow wolf packs and wait for them to make a kill, before stealing it. In Siberia, wolves are also directly preyed upon by tigers. Wolves used to be common throughout most of the United States, Europe and Asia but were extirpated from all

►



Life in a pack is centred around dominance and submission heavily populated areas by the early 20th century. Southern wolves exist only as isolated, endangered populations but the grey wolf is still common in Canada, Alaska and Russia.

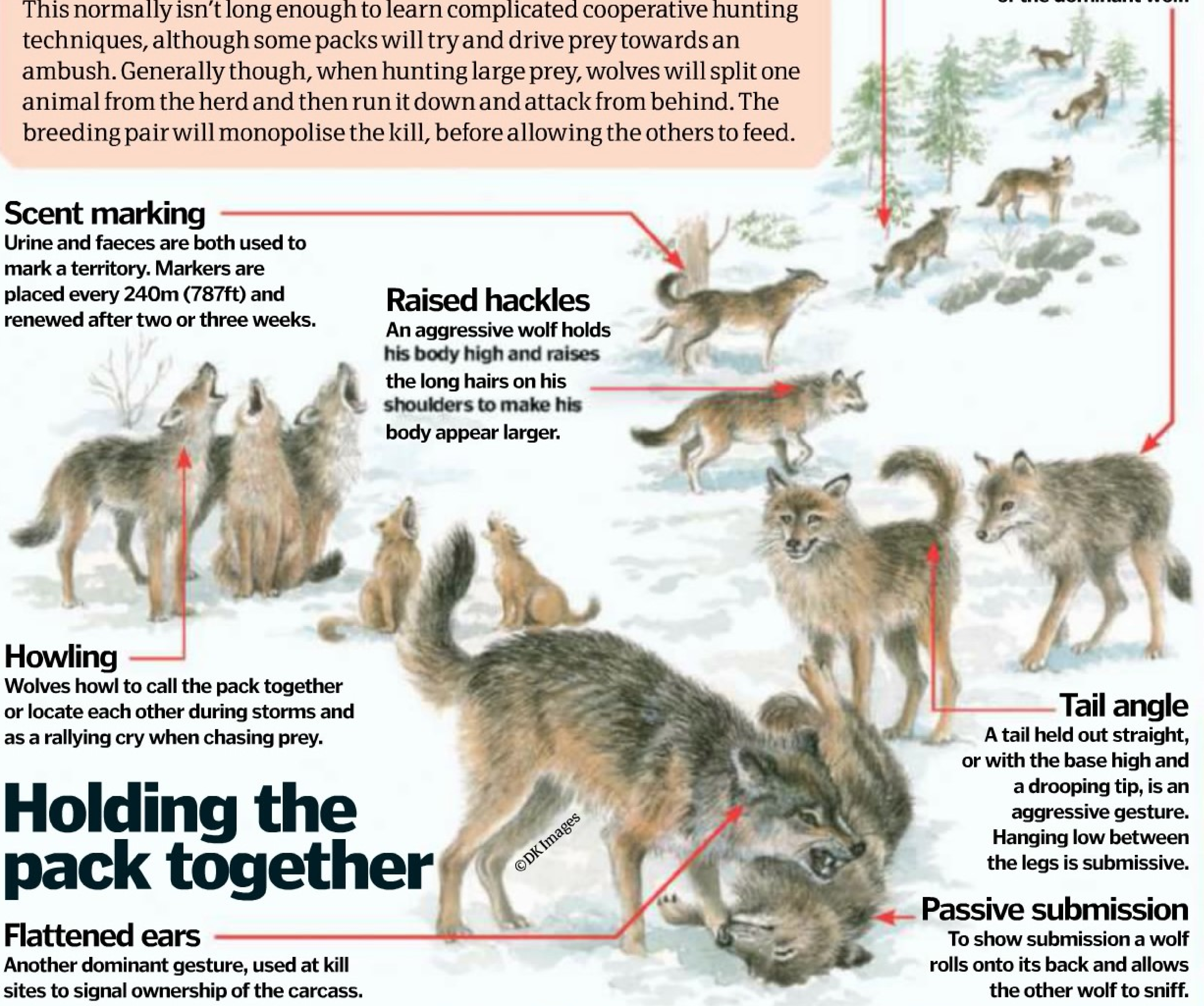
> "Once a herd starts running, the wolves can run alongside and weigh up which are the weakest individuals"

Hungry like the wolf

It's a misconception to think of wolves as pack hunters. While a few large packs of 30 or more individuals have been seen, most are small family groups. Wolves are capable of taking moose and deer on their own or in pairs. A typical wolf pack is a single breeding pair with this year's pups and the youngsters from last year's litter – between 5 and 11 animals all together.

By the age of two, most wolves will move away to start their own pack. This normally isn't long enough to learn complicated cooperative hunting techniques, although some packs will try and drive prey towards an ambush. Generally though, when hunting large prey, wolves will split one animal from the herd and then run it down and attack from behind. The breeding pair will monopolise the kill, before allowing the others to feed.

Holding the pack together



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Boundary disputes
Up to 65 per cent of wolf fatalities are caused by other wolves, at the border between two territories.

Active submission
Used as a form of greeting. The submissive wolf approaches and licks the face of the dominant wolf.

Scent marking
Urine and faeces are both used to mark a territory. Markers are placed every 240m (787ft) and renewed after two or three weeks.

Raised hackles
An aggressive wolf holds his body high and raises the long hairs on his shoulders to make his body appear larger.

Howling
Wolves howl to call the pack together or locate each other during storms and as a rallying cry when chasing prey.

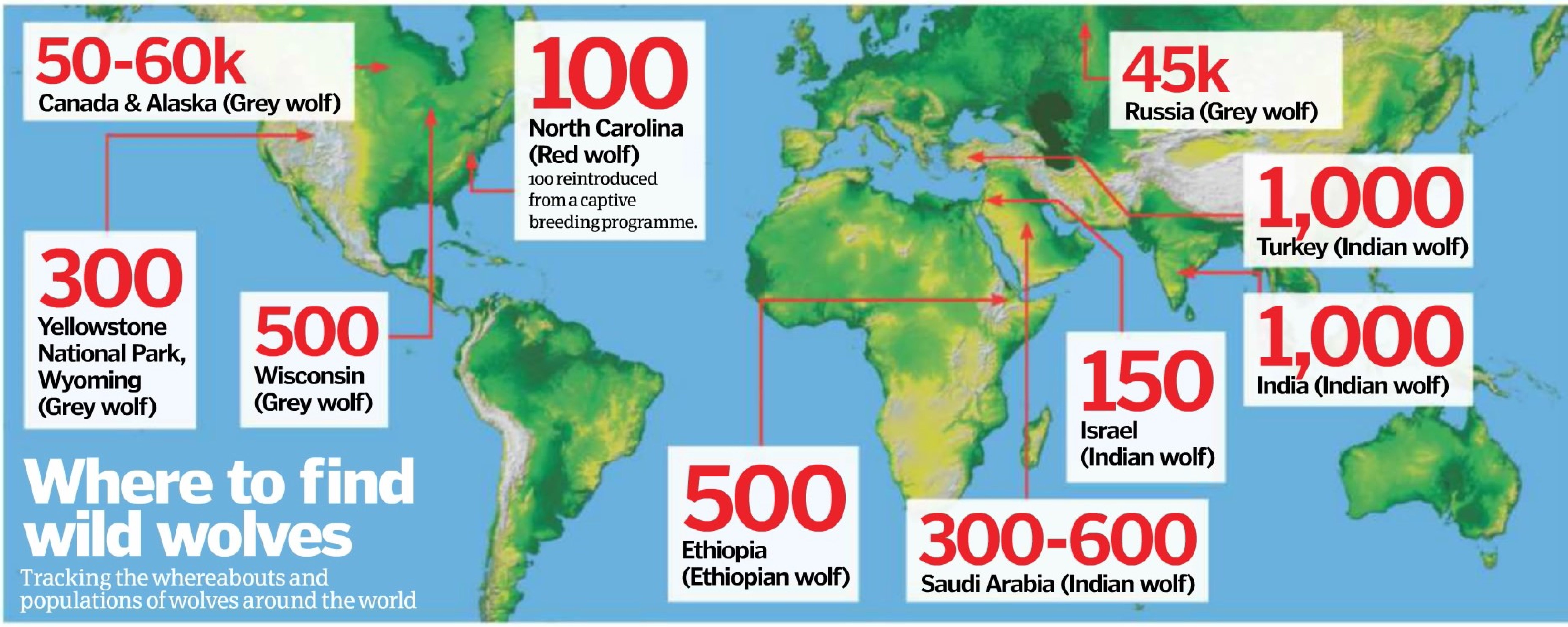
Tail angle
A tail held out straight, or with the base high and a drooping tip, is an aggressive gesture. Hanging low between the legs is submissive.

Flattened ears
Another dominant gesture, used at kill sites to signal ownership of the carcass.

Passive submission
To show submission a wolf rolls onto its back and allows the other wolf to sniff.

Where to find wild wolves

Tracking the whereabouts and populations of wolves around the world



50-60k	Canada & Alaska (Grey wolf)
100	North Carolina (Red wolf) 100 reintroduced from a captive breeding programme.
45k	Russia (Grey wolf)
300	Yellowstone National Park, Wyoming (Grey wolf)
500	Wisconsin (Grey wolf)
1,000	Turkey (Indian wolf)
1,000	India (Indian wolf)
150	Israel (Indian wolf)
500	Ethiopia (Ethiopian wolf)
300-600	Saudi Arabia (Indian wolf)

Head to Head
OTHER SUBSPECIES OF CANIS LUPUS

SMALL

© Pelagund

1. Arabian wolf
A variety of wolf that has adapted to life in the desert, it grows to about 66cm (26in) tall. It has short hair in the summer and a longer coat in winter.

BIG

© Glen Fergus

2. Dingo
A little shorter than the Arabian wolf, but more powerfully built. Originally descended from domesticated dogs that escaped into the wild.

BIGGER

3. Domestic dog
Some dog breeds are tiny, but the Irish wolfhound and deerhound are bigger than most subspecies of wolf. Only the grey and tundra wolves are larger.

DID YOU KNOW? *A wolf has a bite that exerts 10MPa pressure [1,500psi] – twice as much as a German shepherd dog*

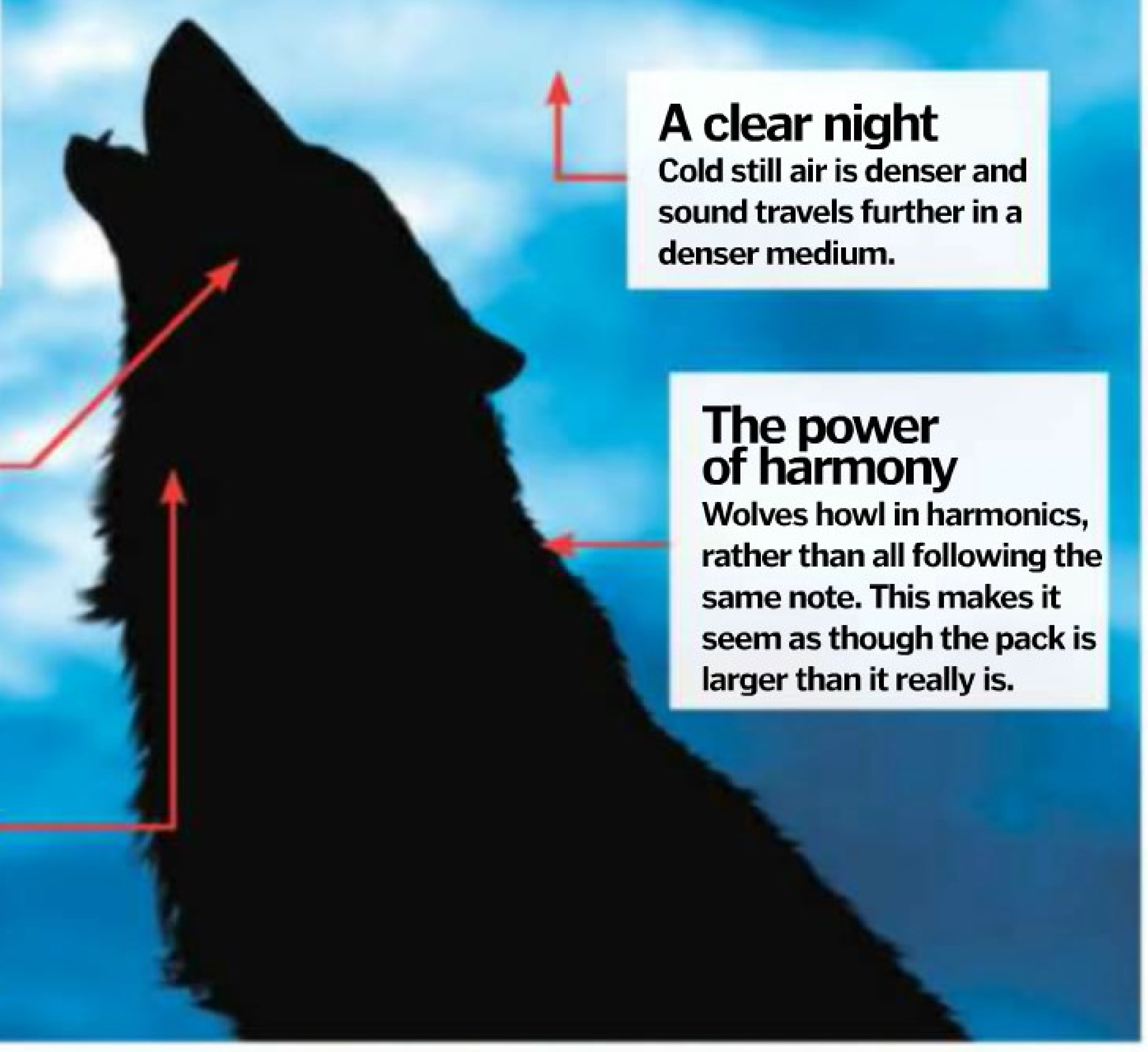
Do wolves really howl at the moon?

No, they don't, they howl at each other. Howling is a long-range signal that allows wolves to reconnect with the pack if they become separated and to warn off rival packs. Howls have a low fundamental frequency of 150-750Hz because low frequencies carry much further, but they also layer this with up to 12 harmonic overtones to exaggerate the number of wolves in a pack. A lone wolf will not risk advertising his presence near the boundary of his territory, but a small group can keep rivals at bay by bluffing that they are more numerous.

As well as howling, wolves will bark as an alarm call, growl and snarl when staking ownership of a kill, and whine when playing or investigating one another.

Canine teeth are used to grip and the carnassials to tear flesh off a carcass

How does a howl travel so far?



A clear night
Cold still air is denser and sound travels further in a denser medium.

Head back
The howl is projected into the air to reduce the amount of scattering from ground clutter.

The power of harmony
Wolves howl in harmonics, rather than all following the same note. This makes it seem as though the pack is larger than it really is.

Long throat
Low frequencies travel further than high ones. Straightening the throat increases the size of the resonating chamber and produces lower notes.

©NASA

A wolf's coat comprises two layers: a thick furry undercoat covered by a layer of longer guard hairs

©Science Photo Library

©Shelley Black

Maya is one member of the Northern Lights Wildlife Wolf Centre pack

INTERVIEW
Shelley Black

Along with her husband, Casey, Shelley has run the Northern Lights Wildlife Wolf Centre in Golden, British Columbia, for ten years. Their aim is to debunk the myths surrounding the wolf and show the critical role that these predators play within an ecosystem

What are the major threats that the wolf faces in the world today?
In Canada it's still legal for a wolf to be hunted, baited and trapped in most areas all year round; these animals are treated like vermin. Beyond the threat of hunting, they're also losing their habitat and food sources to humans [with the expansion of towns and new roads being built, and so on]. In the central Rocky Mountains, in the Banff National Park area, the number one cause of wolf mortality is humans; only five per cent die of natural causes.

How are groups like yours promoting the conservation of the wolf?
We are promoting wolf conservation by speaking to the public, from all around the world, and insisting that we have to stop eradicating wolves from the forest. We're also going into schools to promote this message. By giving hands-on experiences with wolves I think it gives the public a much better understanding of how misrepresented they are. One of the major points we try and get across is how the wolf is a 'keystone species' [one that plays a vital role in maintaining the structure of an ecosystem], as well as a bio-indicator species.

Tell us one characteristic that makes the wolf such a remarkable species.
There are far more than one! They are extremely social and intelligent animals; I'd say one of the few species that can outsmart humans. Their endurance and ability to stay alive never ceases to amaze me.

Generally, what do you find is the public perception of wolves when they first arrive at the Northern Lights Centre?
Most people think they are scary, or they are generally unsure. When they come to the Centre, we inform them that there has never been a proven vicious attack by a healthy non-habituated wolf on a human in the wild. After meeting the wolves themselves, by the time they leave, visitors take away a whole new perspective – which is why we're here.

For more info, see: **www.northernlightswildlife.com**

BIG CATS

What makes these beautiful creatures such consummate experts in the business of killing?

The big cats aren't a single biological grouping. It's an informal term that includes the lion, tiger, jaguar and leopard (sometimes called the Great Cats), as well as the cheetah, cougar, snow leopard and clouded leopard. (The three kinds of leopard actually belong to three different genera and aren't very closely related, despite looking quite similar.) Big cats are all apex predators that hunt large mammals using their excellent camouflage to keep hidden and their powerful muscles to catch and dispatch their prey.

An antelope runs on the very tips of its feet, which allows it to have a much longer stride and means it is very fast. Cats can't do this because they have claws instead of hooves, and they need to retract them to keep them sharp. To catch hoofed animals, the big cats must run with their entire spine flexing to help elongate their effective stride. It's a very energetic technique though and cats can't run fast for long distances. This in turn pushes them to be stealthy in the approach and brutal in the attack. Where a wolf will bite and retreat as it waits for its prey to bleed to death, a cougar will leap onto the back of its prey and crunch straight through the spine with a single bite.

The roar of a big cat is a sound made by the walls of the specially elongated larynx vibrating as the cat exhales, but not all big cats can do it. The cougar, cheetah and snow leopard have no roar, but they do make a variety of other noises, including chirps, screams and growls. All of the big cats are able to climb trees. Leopards are the strongest climbers; indeed, an adult male can haul a young giraffe almost six metres (20 feet) into a tree. This skill enables big cats to protect their kills from hyenas and other pack scavengers that might steal them.

It's easy to think of animals this magnificent in terms of being 'perfectly adapted', but in fact hunting large animals is incredibly difficult and all apex predators hover perpetually close to the brink. If they were anything less than brutally fit, they simply couldn't survive at all.

5 TOP FACTS
FELINE TRIVIA

Top acceleration
1 A cheetah can accelerate from 0-97km/h (0-60mph) in less than three seconds; that's faster than a Ferrari Enzo, a Lamborghini Gallardo or a Porsche 911 Turbo!

Mystery tuft
2 The lion is the only cat which features a furry tuft on its tail. This conceals a spike formed from fused bones at the end of the spine. Its anatomical function is still unknown.

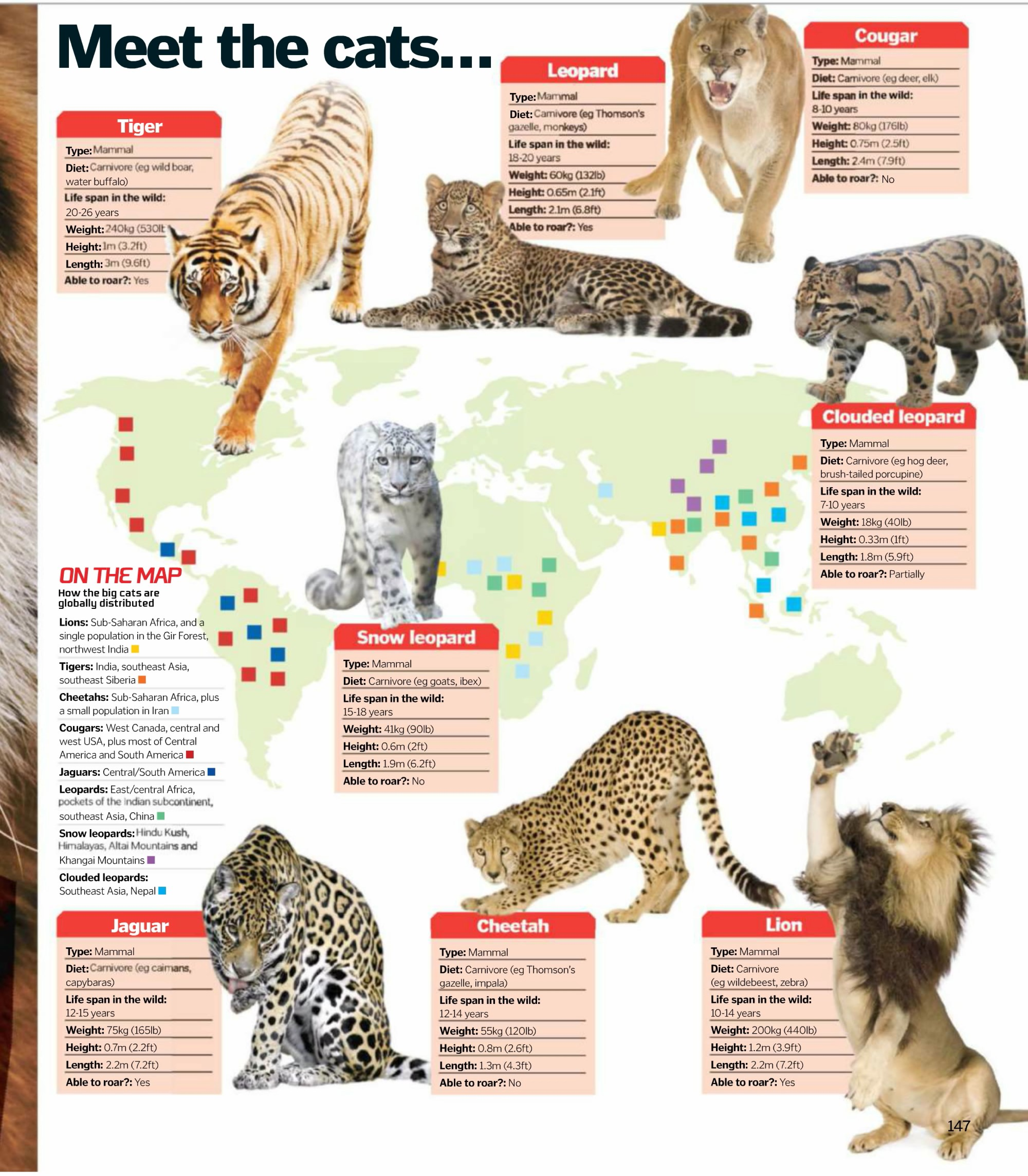
Rise of the panther
3 Panthers aren't separate animals; it's actually just the term for an all-black mutation of a leopard or jaguar. In 1,500 years or so time, all leopards may have evolved to be completely black.

Long leapers
4 Snow leopards prefer to chase prey down a steep hill rather than on flat terrain. This often ends in a huge final leap of up to 14m (46ft), which is roughly the length of a bus.

Deafening roar
5 Lions have the loudest roar of any cat; a male lion's roar can be heard up to 8km (5mi) away. This helps to defend its territory against other males in the vicinity.

DID YOU KNOW? *A leopard will eat anything from a dung beetle up to a 900kg (2,000lb) giant eland*

Meet the cats…



Tiger
Type: Mammal
Diet: Carnivore (eg wild boar, water buffalo)
Life span in the wild: 20-26 years
Weight: 240kg (530lb
Height: 1m (3.2ft)
Length: 3m (9.6ft)
Able to roar?: Yes

Leopard
Type: Mammal
Diet: Carnivore (eg Thomson's gazelle, monkeys)
Life span in the wild: 18-20 years
Weight: 60kg (132lb)
Height: 0.65m (2.1ft)
Length: 2.1m (6.8ft)
Able to roar?: Yes

Cougar
Type: Mammal
Diet: Carnivore (eg deer, elk)
Life span in the wild: 8-10 years
Weight: 80kg (176lb)
Height: 0.75m (2.5ft)
Length: 2.4m (7.9ft)
Able to roar?: No

Clouded leopard
Type: Mammal
Diet: Carnivore (eg hog deer, brush-tailed porcupine)
Life span in the wild: 7-10 years
Weight: 18kg (40lb)
Height: 0.33m (1ft)
Length: 1.8m (5.9ft)
Able to roar?: Partially

ON THE MAP
How the big cats are globally distributed

Lions: Sub-Saharan Africa, and a single population in the Gir Forest, northwest India 🟨
Tigers: India, southeast Asia, southeast Siberia 🟧
Cheetahs: Sub-Saharan Africa, plus a small population in Iran 🟦
Cougars: West Canada, central and west USA, plus most of Central America and South America 🟥
Jaguars: Central/South America 🟦
Leopards: East/central Africa, pockets of the Indian subcontinent, southeast Asia, China 🟩
Snow leopards: Hindu Kush, Himalayas, Altai Mountains and Khangai Mountains 🟪
Clouded leopards: Southeast Asia, Nepal 🟦

Snow leopard
Type: Mammal
Diet: Carnivore (eg goats, ibex)
Life span in the wild: 15-18 years
Weight: 41kg (90lb)
Height: 0.6m (2ft)
Length: 1.9m (6.2ft)
Able to roar?: No

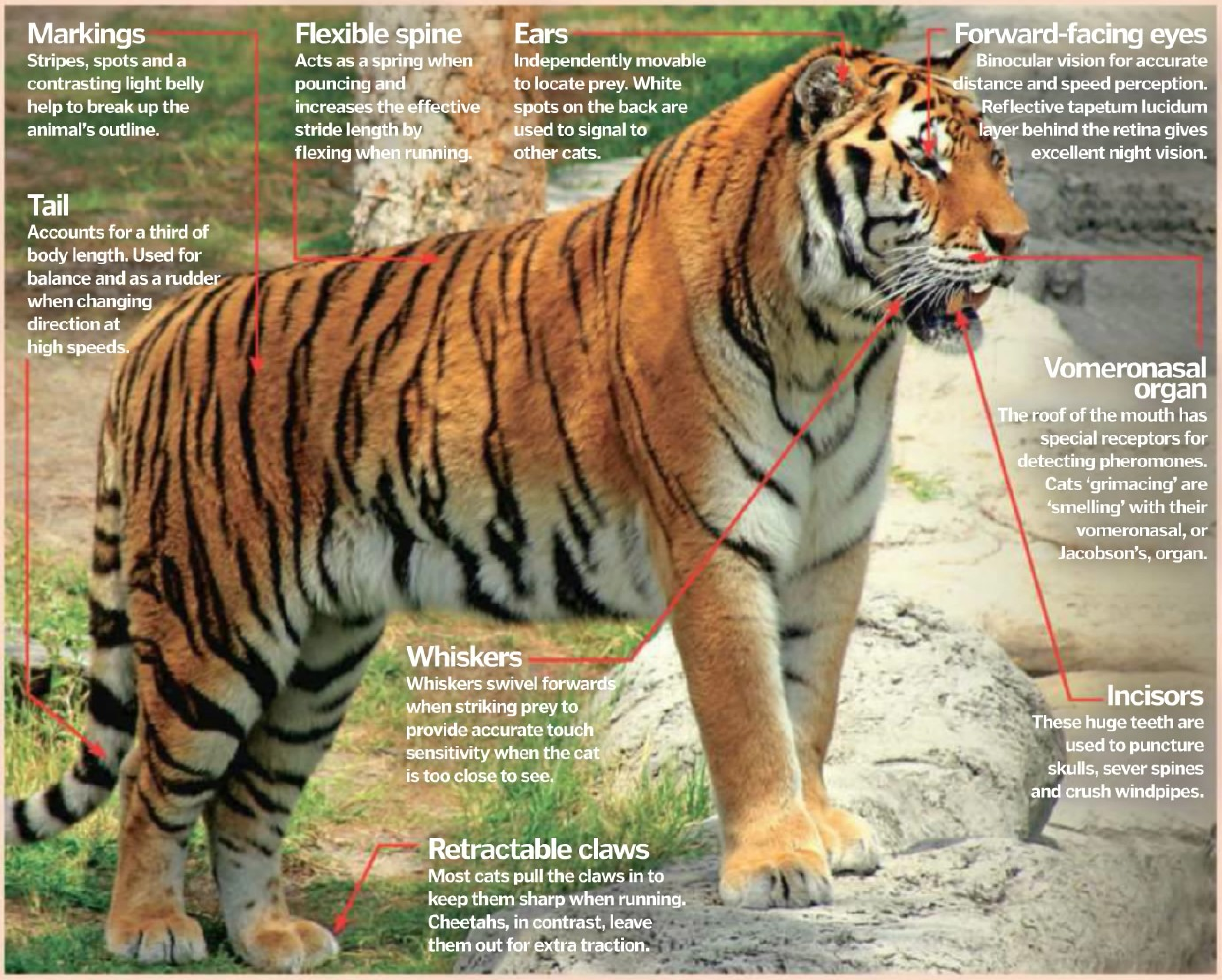
Jaguar
Type: Mammal
Diet: Carnivore (eg caimans, capybaras)
Life span in the wild: 12-15 years
Weight: 75kg (165lb)
Height: 0.7m (2.2ft)
Length: 2.2m (7.2ft)
Able to roar?: Yes

Cheetah
Type: Mammal
Diet: Carnivore (eg Thomson's gazelle, impala)
Life span in the wild: 12-14 years
Weight: 55kg (120lb)
Height: 0.8m (2.6ft)
Length: 1.3m (4.3ft)
Able to roar?: No

Lion
Type: Mammal
Diet: Carnivore (eg wildebeest, zebra)
Life span in the wild: 10-14 years
Weight: 200kg (440lb)
Height: 1.2m (3.9ft)
Length: 2.2m (7.2ft)
Able to roar?: Yes

Purr-fect predators

Want to kill something three times your size? You'll need:



Markings
Stripes, spots and a contrasting light belly help to break up the animal's outline.

Flexible spine
Acts as a spring when pouncing and increases the effective stride length by flexing when running.

Ears
Independently movable to locate prey. White spots on the back are used to signal to other cats.

Forward-facing eyes
Binocular vision for accurate distance and speed perception. Reflective tapetum lucidum layer behind the retina gives excellent night vision.

Tail
Accounts for a third of body length. Used for balance and as a rudder when changing direction at high speeds.

Vomeronasal organ
The roof of the mouth has special receptors for detecting pheromones. Cats 'grimacing' are 'smelling' with their vomeronasal, or Jacobson's, organ.

Whiskers
Whiskers swivel forwards when striking prey to provide accurate touch sensitivity when the cat is too close to see.

Incisors
These huge teeth are used to puncture skulls, sever spines and crush windpipes.

Retractable claws
Most cats pull the claws in to keep them sharp when running. Cheetahs, in contrast, leave them out for extra traction.

Threats to the big cats

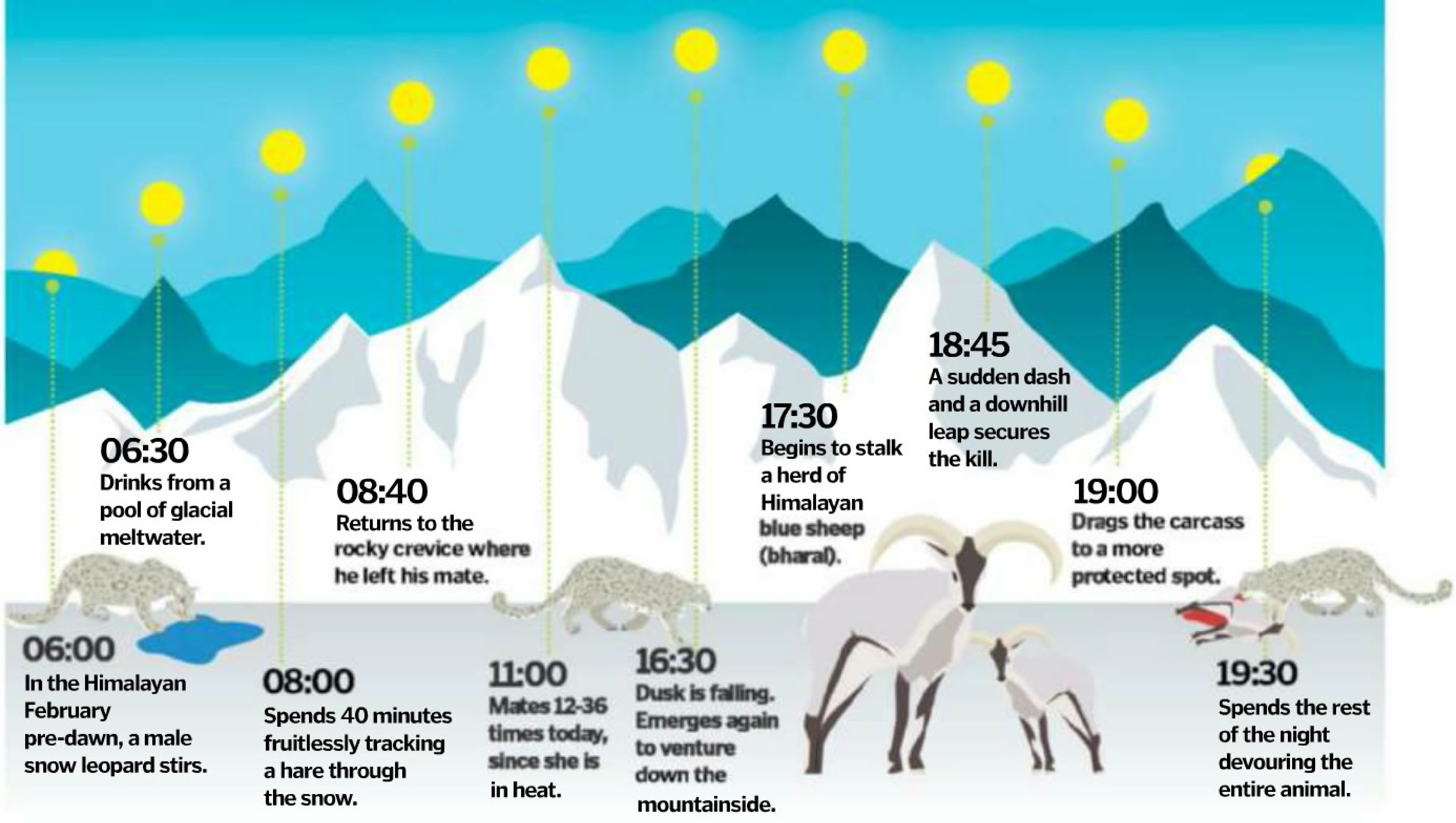
Top carnivores are inherently vulnerable species. They require large home ranges and reproduce relatively slowly. Lions, leopards and cheetahs all suffer high infant mortality from other predators – indeed, up to 90 per cent of cheetah cubs are lost. Cheetahs also have very low genetic variability, possibly due to an extreme population bottleneck thousands of years ago, leading to birth defects as a result of inbreeding; captive breeding schemes have had very limited success. The biggest threats to big cats, though, are habitat loss due to human expansion and poaching. Although most cats have a wide geographic distribution, human development has fragmented these ranges into pockets, each of which may be too small for them to flourish in the long term.

Feuding families

Most big cats are solitary creatures. Female tigers, cougars, jaguars and leopards will maintain a territory of roughly 15-25 square kilometres (5.8-9.7 square miles) and raise their cubs alone. The male has a much larger territory – indeed, cougars have been reported with territories as extensive as 1,300 square kilometres (500 square miles) – but this is to control access to females, not food.

In the big cat kingdom, lions are unusually social because they hunt in the open and need to co-operate to have any chance of success. A typical pride consists of five or six females and one or two males, along with several cubs. Females do most of the hunting; males overheat too easily with their large manes. Males that join a pride will normally start by killing all the cubs. Females are very promiscuous and mate 20-40 times a day when in heat; this makes it harder for males to tell which cubs are theirs and so reduces the rate of infanticide.

A day in the life of a snow leopard



06:00
In the Himalayan February pre-dawn, a male snow leopard stirs.

06:30
Drinks from a pool of glacial meltwater.

08:00
Spends 40 minutes fruitlessly tracking a hare through the snow.

08:40
Returns to the rocky crevice where he left his mate.

11:00
Mates 12-36 times today, since she is in heat.

16:30
Dusk is falling. Emerges again to venture down the mountainside.

17:30
Begins to stalk a herd of Himalayan blue sheep (bharal).

18:45
A sudden dash and a downhill leap secures the kill.

19:00
Drags the carcass to a more protected spot.

19:30
Spends the rest of the night devouring the entire animal.

RECORD BREAKERS
CAT ALIASES

40+

ANIMAL WITH THE MOST NAMES

The cougar is the animal with the most folk names. These include catamount, ghost cat, puma, shadow cat, mountain lion, deer tiger, silver lion, devil cat and catawampus.

DID YOU KNOW? *If you shave a tiger of its fur the skin beneath will still be stripy*

Hunting techniques

Big cats generally hunt between sunset and dawn. They are ambush predators that move silently through dense undergrowth using their excellent vision and hearing to spot their prey before their prey spots them. Although they are all incredible sprinters, big cats lack stamina. A cheetah may exhaust itself so badly in a 60-second dash that it needs half an hour to recover and most cats will give up if they cannot run down their quarry in 30 seconds. Accordingly, they always attack from a position of advantage, leaping from cover or a tree branch, etc. Tigers will even launch attacks from the riverbank into the water and are strong enough swimmers to take on crocodiles.

What's on the menu?

Hunting big game is an erratic profession. Cheetahs can generally manage a 50 per cent success rate but a tiger may only kill its prey one time in every 20 attempts. Consequently, they need to be able to make the most of each kill. Lions will eat 30 kilograms (66 pounds) of meat in one sitting, while jaguars can eat 25 kilograms (55 pounds) – a third of their body weight; that is the equivalent of you eating over a hundred Big Macs in one sitting! After a meal like that, lions, tigers, cougars and snow leopards can go for up to two weeks without eating again. Big cats are all quite opportunistic hunters. As well as their favoured prey of medium to large herd animals, they will eat monkeys, rodents, lizards, porcupines and birds' eggs. Many cats – especially the forest dwellers – will also eat insects and a small amount of fruit and vegetation.

Strangulation

The most common attack technique, used by all big cats, is to lunge at the neck and clamp down on the windpipe with powerful jaws. This cuts off the air supply and prey that is already out of breath from the chase quickly loses consciousness.

Asphyxiation

Another way to achieve the same result is to take a wide bite and clamp over the victim's mouth and nostrils, so it can't breathe. Lions and occasionally leopards will use this technique on antelope, but it isn't suitable for larger prey like zebra.

Neck breaking

The largest cats can leap on the back of an animal and bite right through its neck, severing the spine. This paralyses the victim instantly and ends the struggle, but it requires tremendous bite force. Lions, tigers and cougars all use this method.

Artery slicing

In the chaos of the final lunge, a cat may miss the windpipe of its prey and instead slice open the carotid artery. This is a slightly slower kill but it still gets the job done, as the victim will bleed to death.

The paw swipe

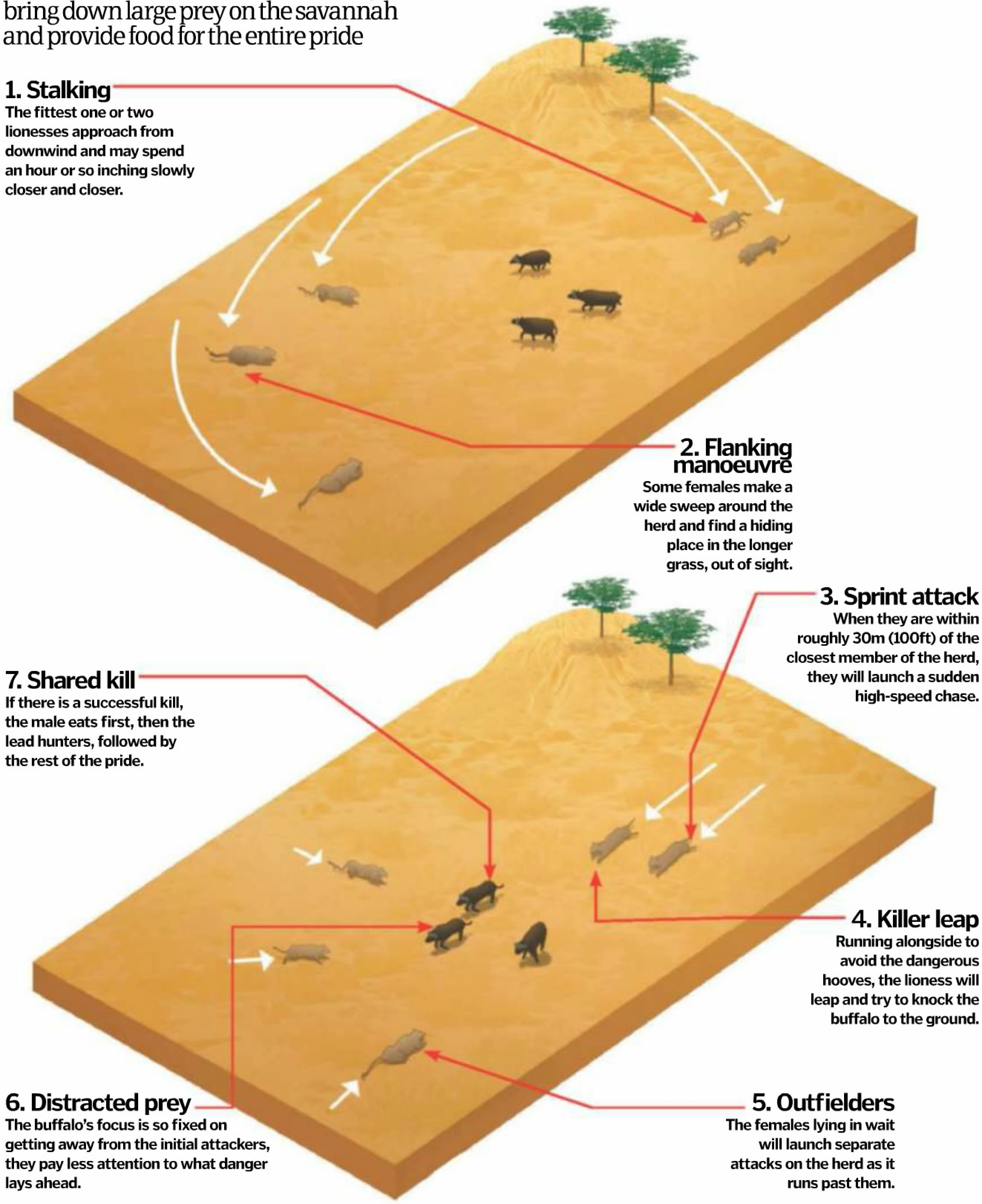
Lions and tigers are so strong that they can kill merely with a swipe of their paws. Tigers in particular have been witnessed swiping at adult domestic cattle with enough force to shatter the skull.

Skull piercing

The jaguar has the strongest bite of any cat – twice as powerful as the much larger lion. This may have evolved to enable them to bite through the shells of turtles, but jaguars also use it for a unique finishing move: their canine teeth can puncture an animal's skull and pierce the brain.

How lions hunt

Lionesses work as a team to efficiently bring down large prey on the savannah and provide food for the entire pride



1. Stalking
The fittest one or two lionesses approach from downwind and may spend an hour or so inching slowly closer and closer.

2. Flanking manoeuvre
Some females make a wide sweep around the herd and find a hiding place in the longer grass, out of sight.

3. Sprint attack
When they are within roughly 30m (100ft) of the closest member of the herd, they will launch a sudden high-speed chase.

4. Killer leap
Running alongside to avoid the dangerous hooves, the lioness will leap and try to knock the buffalo to the ground.

5. Outfielders
The females lying in wait will launch separate attacks on the herd as it runs past them.

6. Distracted prey
The buffalo's focus is so fixed on getting away from the initial attackers, they pay less attention to what danger lays ahead.

7. Shared kill
If there is a successful kill, the male eats first, then the lead hunters, followed by the rest of the pride.

Ligers and tigons

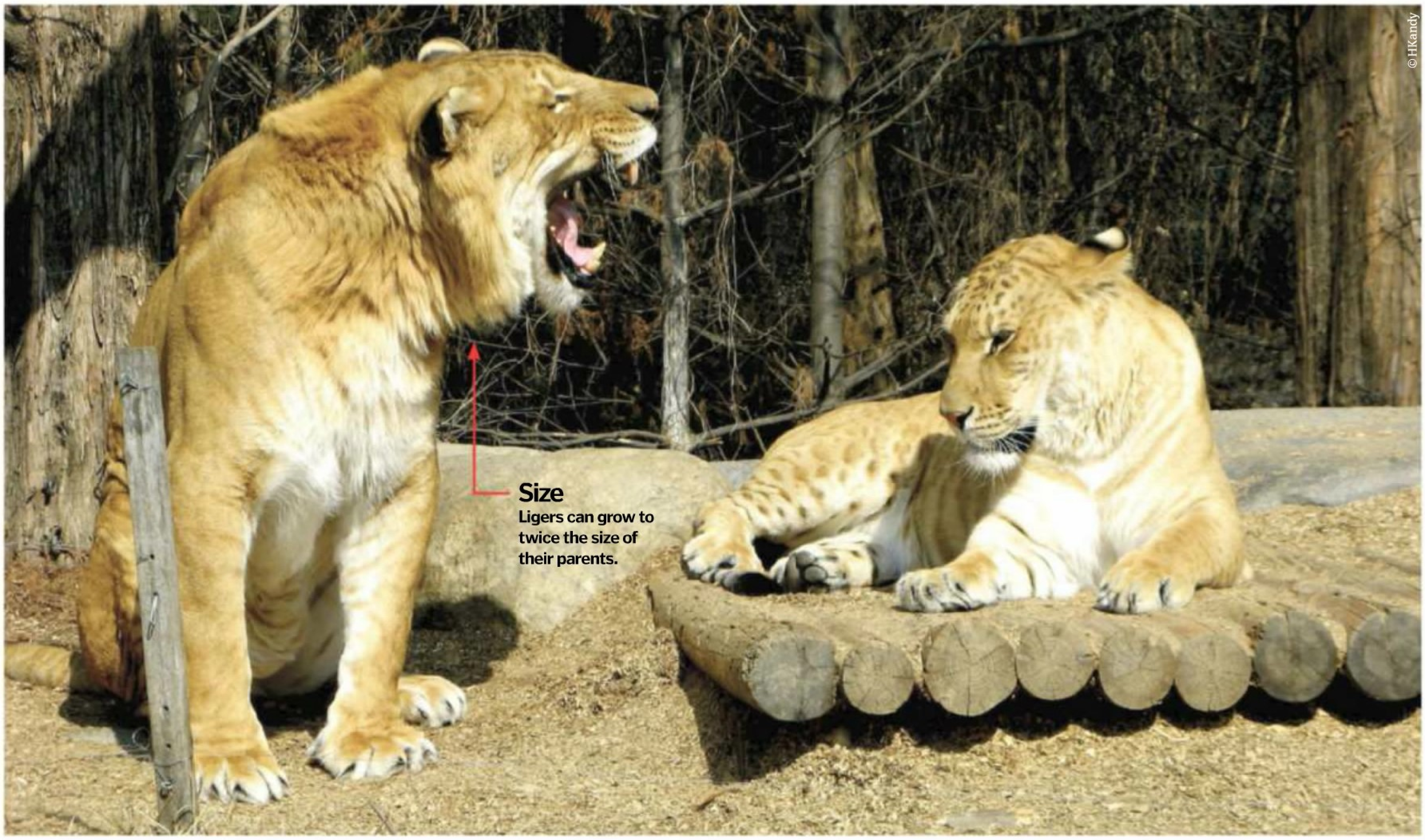
When lions and tigers mate, new species are born

Ligers and tigons are two resultant species that emanate when lions and tigers cross breed. If a male lion mates with a tigress then a liger is born, if a male tiger mates with a lioness then a tigon is born. Both hybrid species are extinct in the wild as their respective habitats lead to minimal interaction, however many examples of both species can be found in captivity across the world in zoos and wildlife parks.

Ligers are now the more prevalent of the two species due to the greater probability of them living past birth, although during the early 20th Century this was not the case. The liger, as with the tigon, shares characteristics from both parent species – ligers enjoy swimming for example, a trait which is associated with tigers, however they also have spots, a characteristic gene of the lion – and tend to be bigger due to imprinted genes. Indeed, the current largest liger in the world weighs over 400 kilograms and is twice the size of its parents. Interestingly, though, tigons tend to suffer from dwarfism rather than gigantism as they always inherit the growth-inhibitory genes from the lioness mother, often weighing only around 200 kilograms.

Unfortunately, due to the hybrid man-made nature of ligers and tigons, growth disorders and degenerative diseases are common, as well as shortened life spans.

A male liger in Novosibirsk Zoo, Russia



© HKandy

Size
Ligers can grow to twice the size of their parents.

THE STATS
HIPPO FACTS AND FIGURES

AVERAGE LIFE SPAN **50yrs** KILL COUNT **300+ people per year**

ROAR **115 decibels** LENGTH **4m (13ft)** MAX WEIGHT **3 tons**

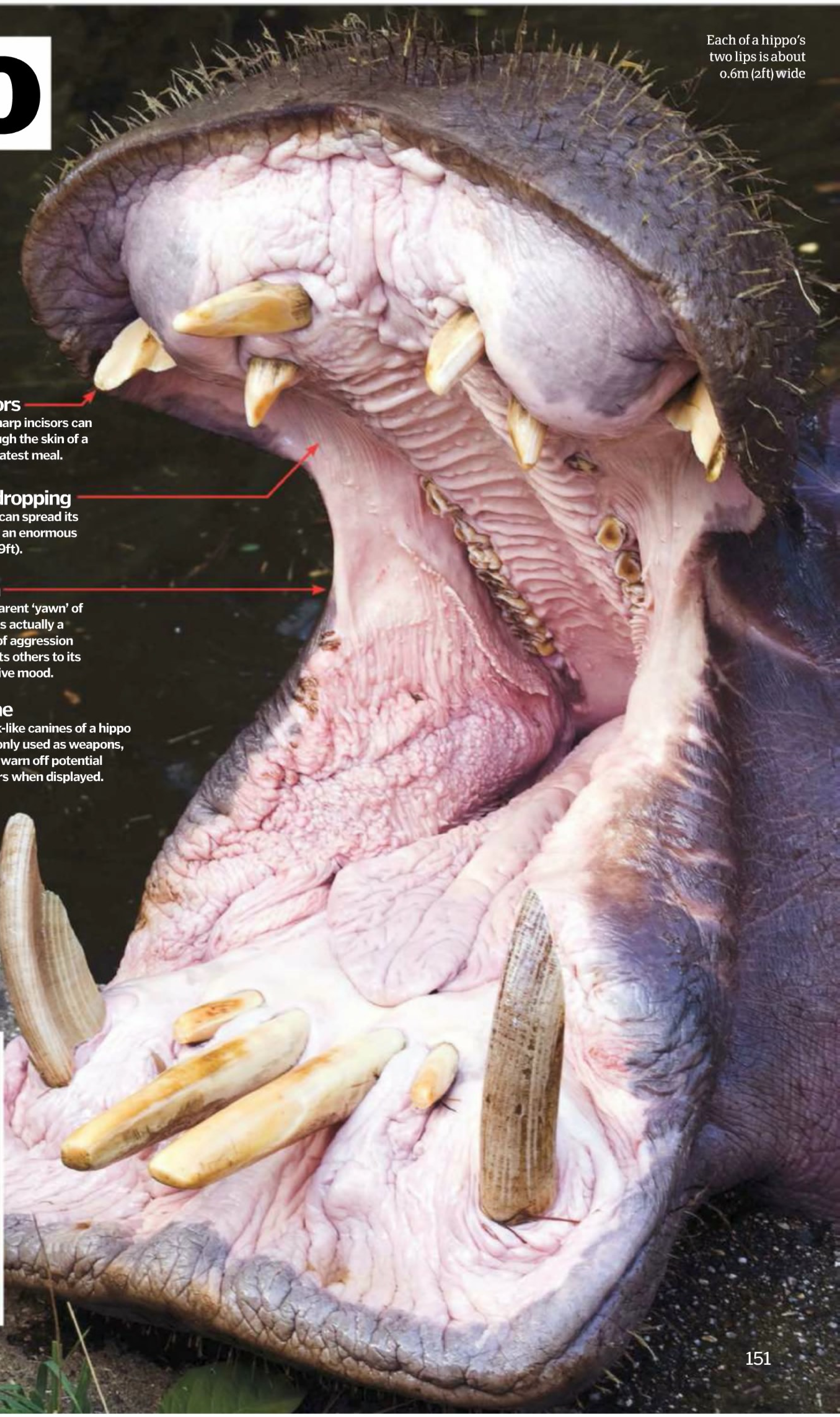
DID YOU KNOW? Despite their bulk, hippos have been known to reach speeds of 30mph (48km/h)

Hippo jaws

Why do these water-dwelling creatures open their mouths so wide?

A hippo may open its mouth wide as a sign of aggression, similar to other animals such as lions and baboons. Opening their jaws shows others their fearsome set of weaponry: their teeth.

Although hippos eat vegetation, they do not use their teeth to do so. Their giant canines and incisors are used only for killing. Instead, they use their huge lips to rip grass from the ground for consumption. A hippo is able to spread its lips through a jaw-dropping 150 degrees and up to 1.2m (3.9ft) in width. The strength of a hippo's jaw muscles – a bite force of 1,800lb – is such that it can use its fearsome teeth to bite a crocodile, human, or even a small boat in half.



Each of a hippo's two lips is about 0.6m (2ft) wide

Incisors
Razor-sharp incisors can rip through the skin of a hippo's latest meal.

Jaw-dropping
A hippo can spread its gums to an enormous 1.2m (3.9ft).

Yawn
The apparent 'yawn' of a hippo is actually a display of aggression and alerts others to its aggressive mood.

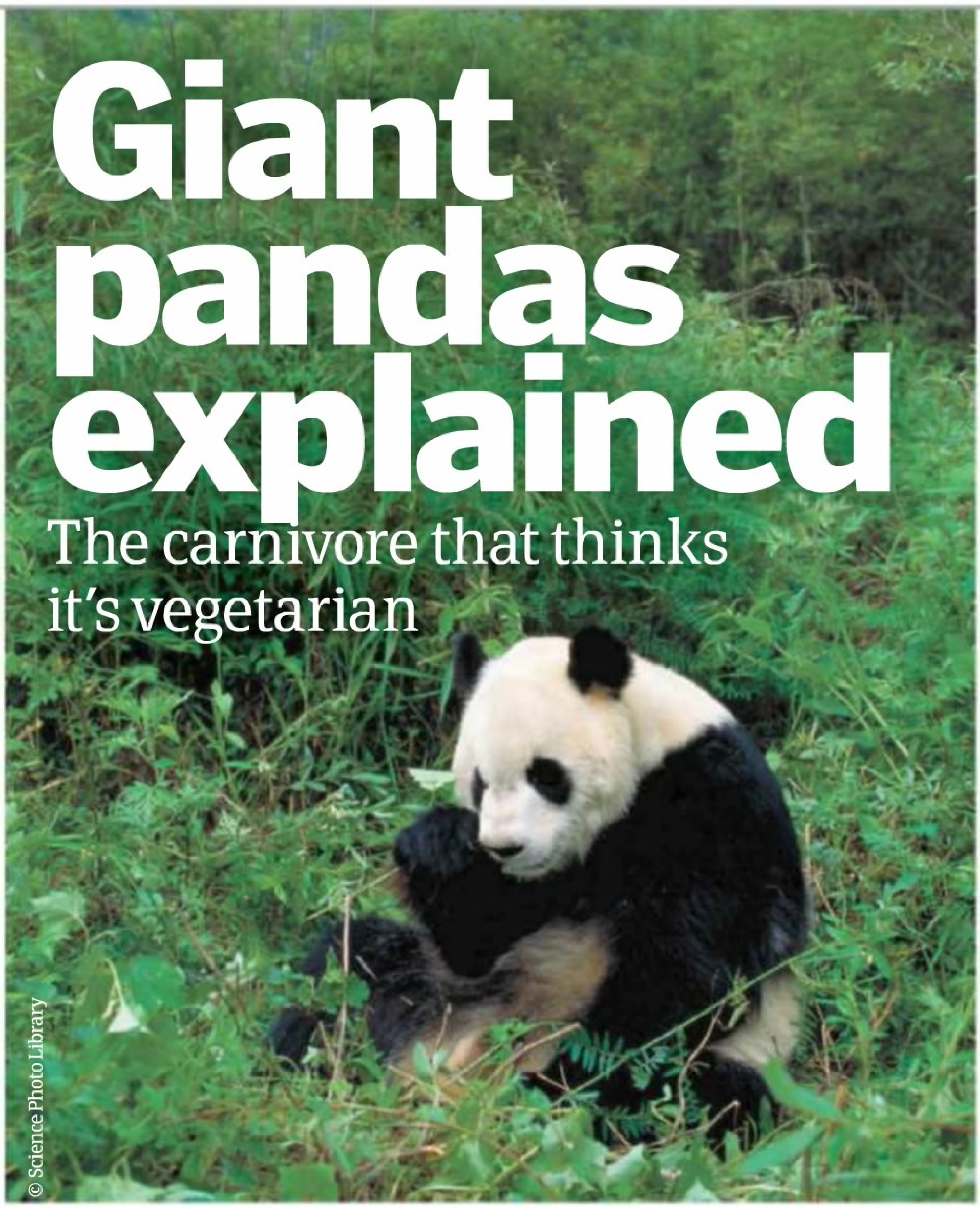
Canine
The tusk-like canines of a hippo are not only used as weapons, but also warn off potential predators when displayed.

The skull of a hippopotamus contains tusk-like canines as long as your arm

© Raul654

Giant pandas explained

The carnivore that thinks it's vegetarian



© Science Photo Library

There he sits, the giant panda. Solitary, peaceful, resting upright on his furry haunches like a black-and-white Buddha. A born carnivore, this perplexing member of the bear family passes on the meat course almost entirely, choosing instead to persist with nature's version of a celery diet: bamboo.

A highly endangered animal – less than 2,500 exist in the wild – the panda's monotonous (nearly monovorous) diet is part of its undoing. The nutritional value of bamboo is negligible, exacerbated by the fact that the panda is genetically incapable of digesting cellulose. The result is that much of the panda's extremely high-fibre diet passes right through it, providing only minimal calories to an animal that can grow up to 136kg (300lbs) in the wild.

So there the giant panda sits, for up to 16 hours every day, tearing and grinding away at piles of this nearly indigestible plant simply to eke out enough caloric energy to wake up the next day and do it all again. That peaceful, almost Zen-like demeanour has less to do with temperament than low blood sugar. The poor panda can hardly muster the energy to mate, and when he does successfully reproduce, the female will only raise one young at a time, even though the majority of births are twins. Such a slow reproductive rate makes the giant panda population highly susceptible to outside pressures, of which there are many.

Habitat loss is the panda's greatest threat, then poaching. Because of their singular devotion to bamboo, pandas must live where the plant is abundant. Today, the only suitable habitat is limited to 20 isolated sections of mountain forest in south-western China, all of which have thankfully been protected by the Chinese government with help from conservationist organisations like the World Wildlife Fund.

A newborn panda is practically hairless

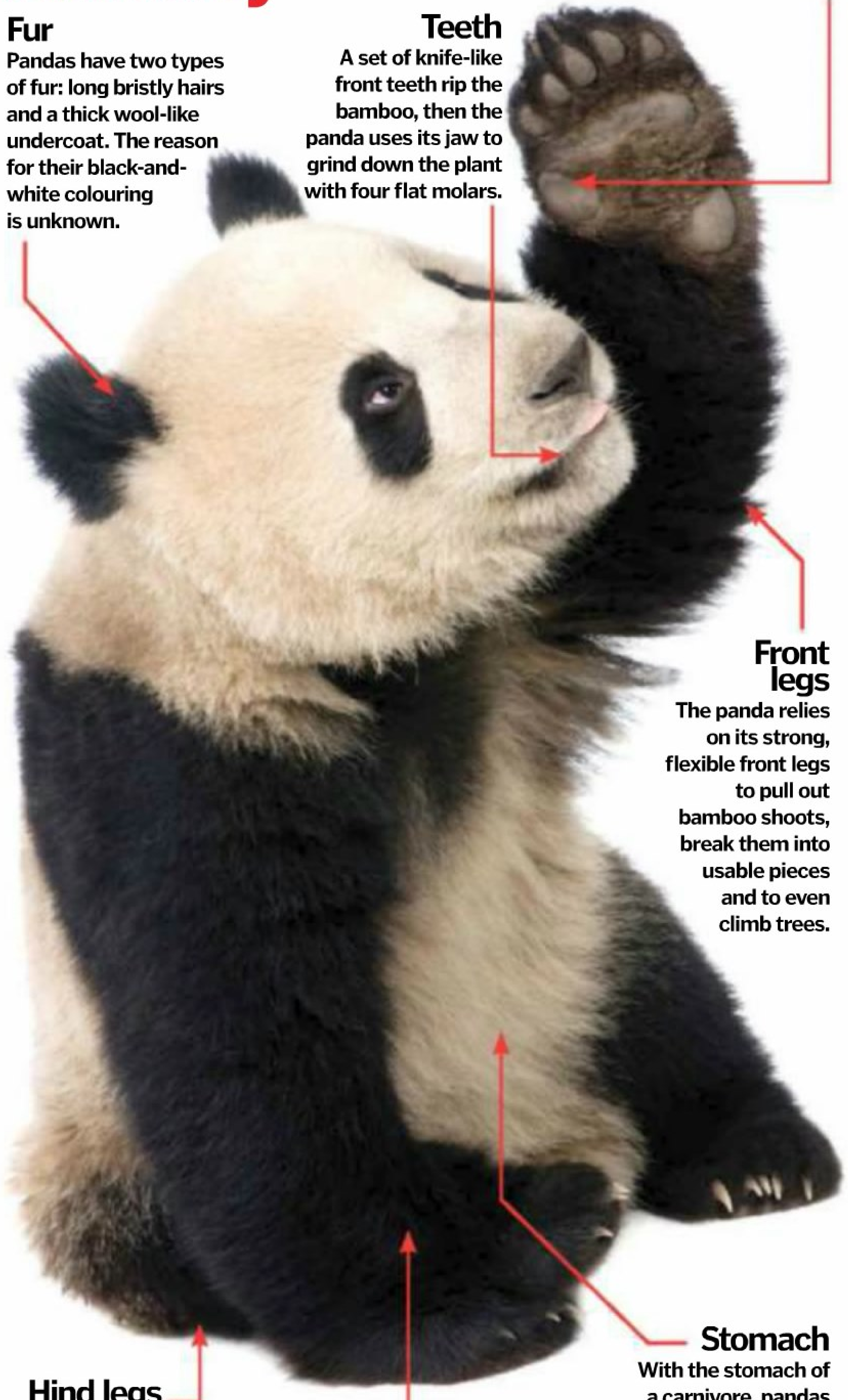
© The GIMP

Calories from food

The amount of energy an animal obtains from food is measured in calories. The following information reveals how many calories a panda must consume per day compared with other creatures.

ANIMAL	CALORIES CONSUMED PER DAY
Elephant	40,000
Giant panda	20,000
Adult humans	2,300-2,600
Mouse	20

Giant panda anatomy



Paws
A pseudo-thumb, an elongated wrist bone covered with a thick pad of skin, is used for grasping bamboo stalks.

Fur
Pandas have two types of fur: long bristly hairs and a thick wool-like undercoat. The reason for their black-and-white colouring is unknown.

Teeth
A set of knife-like front teeth rip the bamboo, then the panda uses its jaw to grind down the plant with four flat molars.

Front legs
The panda relies on its strong, flexible front legs to pull out bamboo shoots, break them into usable pieces and to even climb trees.

Hind legs
The panda's hind legs are spread widely apart, helping it to sit comfortably for hours on end, but making it difficult to run.

Skin
The skin under a panda's black fur is grey and the skin under its white fur is pink. Newborn pandas are entirely pink and nearly hairless.

Stomach
With the stomach of a carnivore, pandas rely on microbes to help break down the abundant cellulose in bamboo. A thick layer of mucus protects against splinters.

Head to Head
ENDANGERED CREATURES

RARE

1. Polar bears

As the polar ice caps shrink, so too do the hunting grounds of this magnificent animal, which could be extinct in the wild within the century.

RARER

2. Mountain gorilla

The WWF estimates that only 720 of these majestic gorillas remain in fragile habitats threatened by ongoing African wars.

RAREST

© Doniv79

3. White-headed langur

Confined to Cat Ba Island off the coast of Vietnam, only 59 exist in the wild where they are illegally hunted for 'monkey balm'. Golden langur pictured.

DID YOU KNOW? A giant panda cub weighs 142g (5oz) at birth, approximately 1/900th the size of its mother

The statistics…

Giant panda

Species: Ailuropoda melanoleuca

Type: Mammal

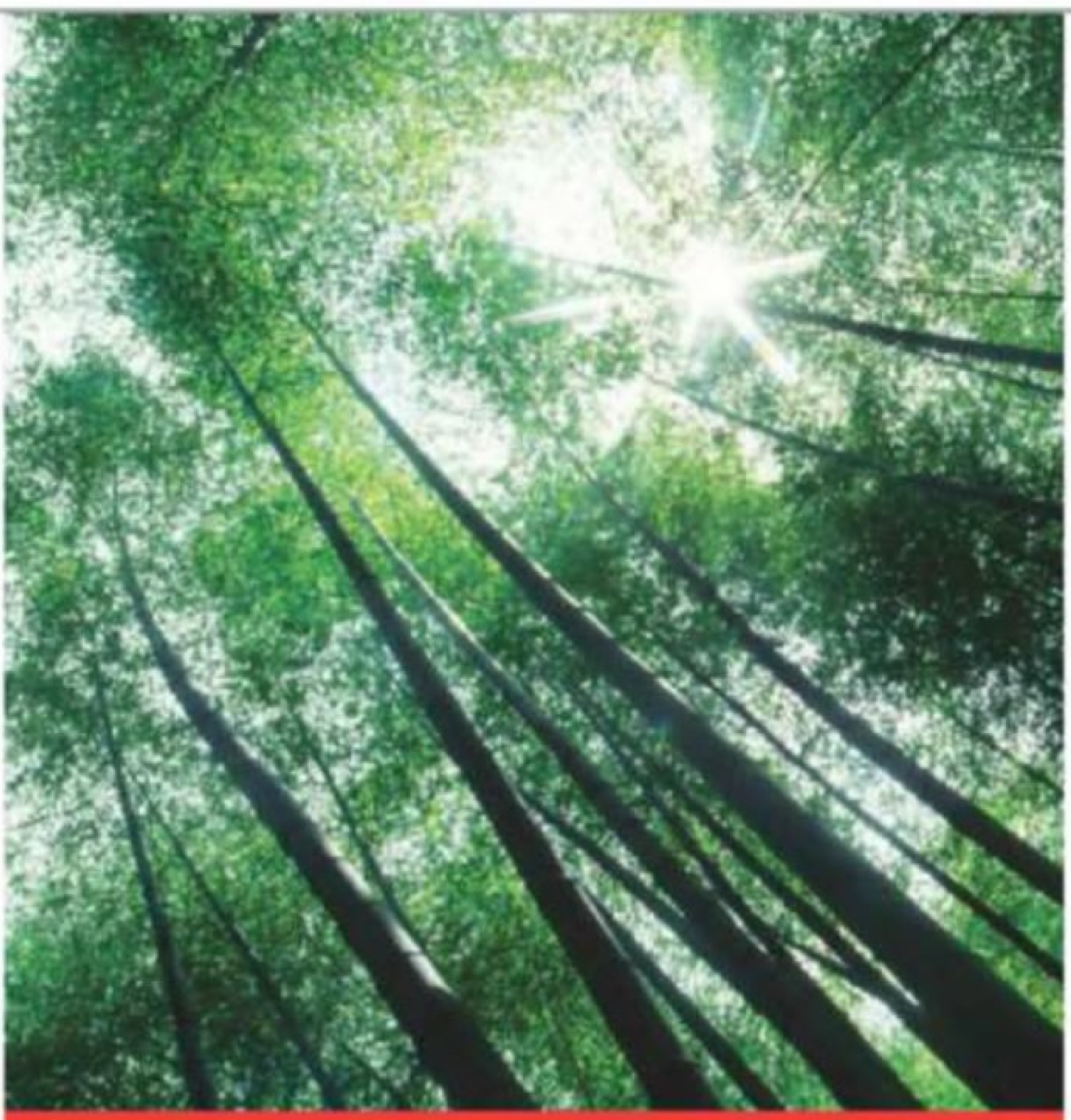
Diet: Omnivore

Average life span in the wild: 20 years

Weight: Up to 136kg (300lbs)

Size: Up to 2m (6ft) head to tail and 1m (3ft) at the shoulders

Without opposable thumbs, the panda had to adapt to grip bamboo



Adapting to bamboo

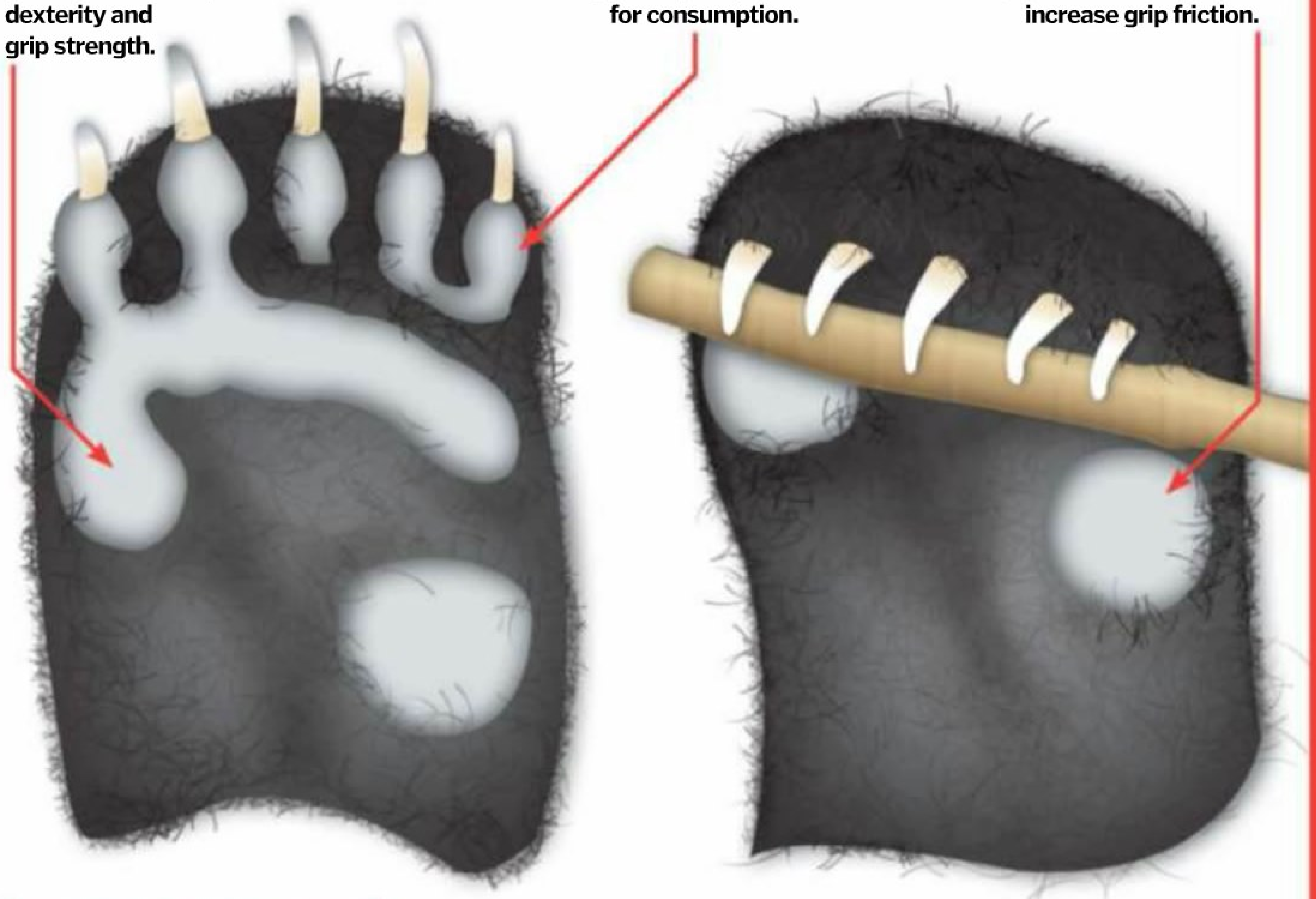
It's the diet they were designed for, so why do pandas shun meat?

Although giant pandas are technically carnivores, they have adapted to eating a diet of 99% bamboo, which they can barely digest. Pandas are genetically unable to turn cellulose into energy, so they must eat up to 38kg (84lbs) of the fibrous plant every day to get enough calories to survive. The task requires 12-16 hours of foraging and eating.

The panda's gut has developed a thick layer of mucus to protect against bamboo splinters. So, aside from the rare rodent or bird, why don't pandas eat meat? Clues in the recently sequenced panda genome point to a genetic mutation that may render them unable to taste flesh. Fossil studies show that the giant panda's ancestors swapped meat for bamboo somewhere between 2 and 7 million years ago – perhaps due to a major environmental event wiping out their prey. Being forced to change their diet may have caused the gene responsible for tasting savoury foods to become obsolete, and without it they might not have wanted to eat the tasteless meat even when it became plentiful.

A 'carnivorous' panda will opt for bamboo over meat, every time

The grip of a panda…

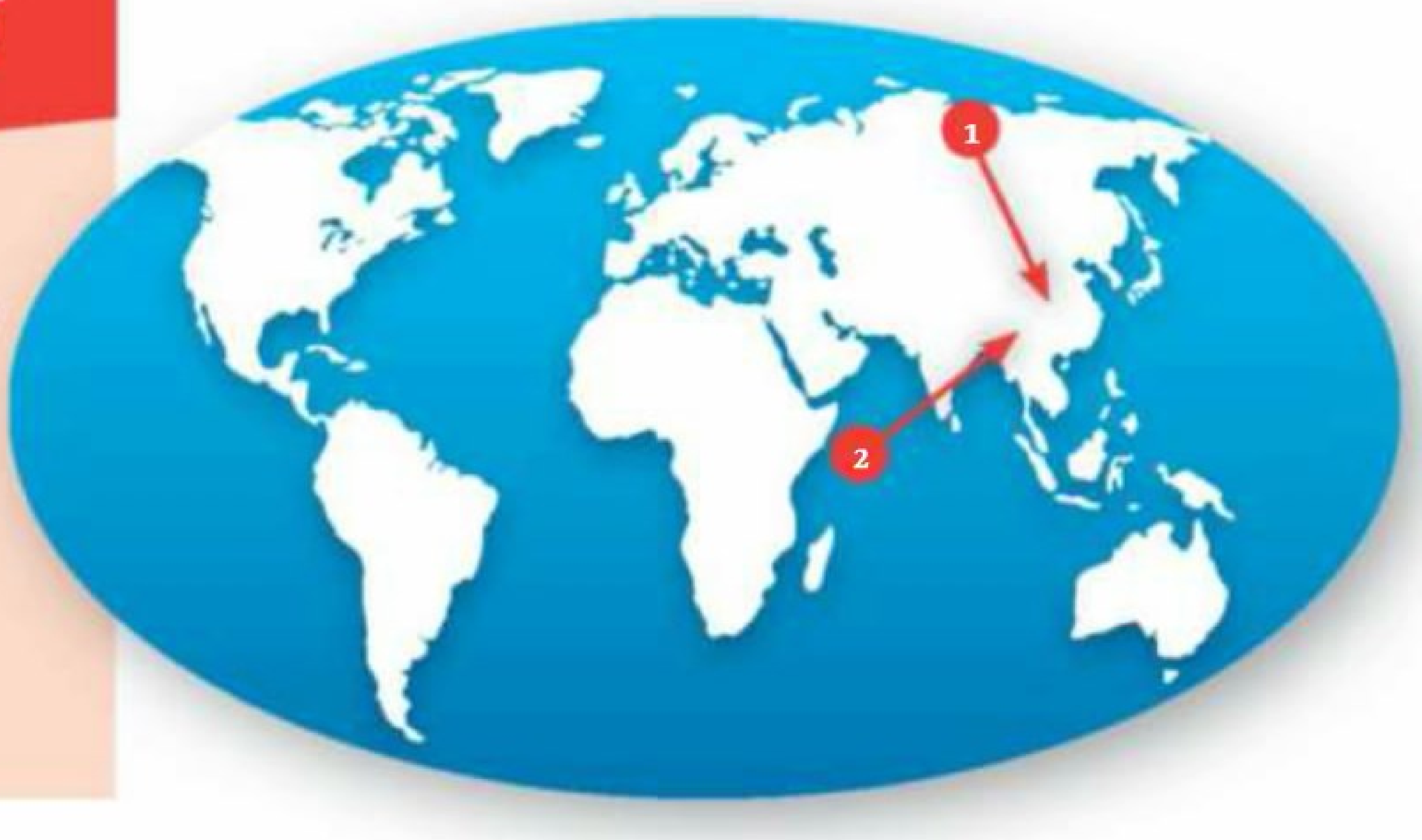


Thumb
An evolved bone pseudo-thumb helps dexterity and grip strength.

Fingers
Five strong, bulbous fingers help strip bamboo for consumption.

Pads
Toughened skinned pads have developed to increase grip friction.

ON THE MAP



Where the wild pandas are…

1 Minshan mountains: 45% of the wild panda population live in these biodiverse Chinese mountain forests.

2 Qinling mountains: 200-300 pandas live on the cool, wet southern slopes of this Chinese range.

The life of elephants

Elephants are big in every sense of the word, but also surprisingly sensitive. Here we unpack some of the myths and explain what makes them so special

Elephants are the largest land animals in the world, with African males averaging five tons. They have evolved to this huge size to protect themselves from predators but almost everything that makes an elephant unique is a consequence of this bulk. Large mammals don't have enough skin surface area to shed excess body heat so elephants have large flapping ears to act as radiators. A heavy head precludes a long neck so elephants have evolved a trunk, both to stretch up into branches and to be able to reach down to the ground to drink.

Most mammals stand with their leg joints half bent, which makes it easier to accelerate from a standstill. Elephants can only support their body weight by keeping the bones all in a line, like a pillar. Humans are the only other animal that does this. Elephants do not have fused ankle joints, as some people think, but it is true that they do not jump. The impact stresses would risk serious injury if they tried. This is the same reason that elephants don't gallop. Instead, they have a curious half-jogging gait where the front legs run and the hind legs walk fast.

Elephants used to be classified as pachyderms and lumped with the rhino and hippopotamus. Scientists now place them in their own order, the proboscidea, along with the extinct mammoths. There are three species of elephant living today: the African Bush elephant, African Forest elephant and the Asian elephant. All elephant species are protected but poaching is a very serious problem and current population numbers are unknown.

5 TOP FACTS ELEPHANTS

No stick in the mud

1 Elephant feet spread out underneath their weight but shrink again when lifted. This lets elephants break the suction when they are walking through deep mud.

Bendy knees

2 Elephants are the only animal to have four forward-facing knees. All other four-legged animals have at least one pair of legs with knees that face backwards.

Thirsty work

3 Hanging around the savannah is thirsty work and the average elephant drinks more than 200 litres of water per day. That's around two very deep bathfulls!

The daily grind

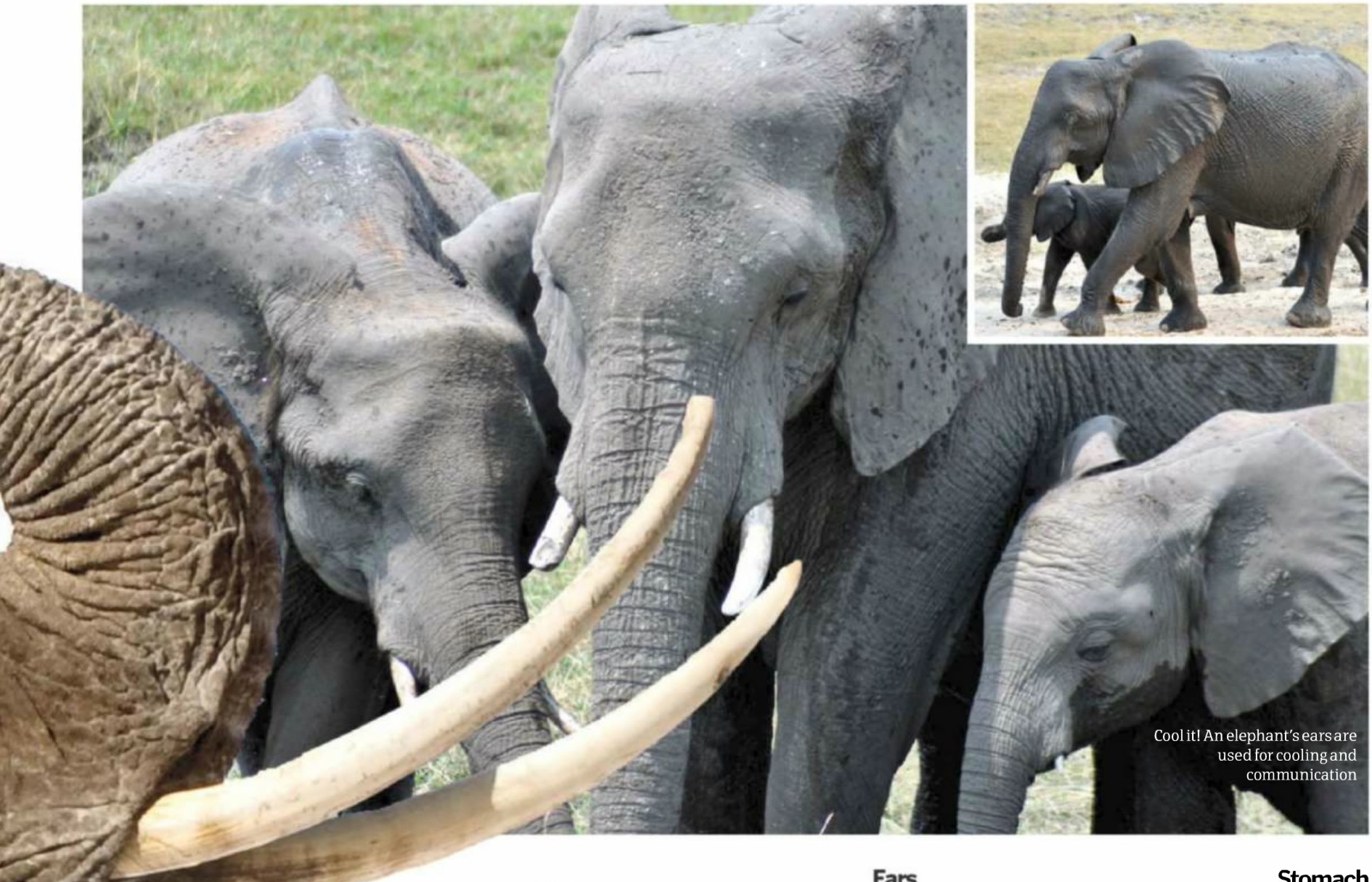
4 Elephants replace their teeth six times in their life, with new teeth moving forward from the back of the mouth. When the last set wears down, the elephant dies of starvation.

Don't try to outrun one

5 They may not look fast and although elephants take a long time to accelerate during a charge they can, in fact, reach 40km/h (25mph). Quite a speed for its size!

DID YOU KNOW? Elephants are either right- or left-tusked. The 'master tusk' wears down quicker from extra use

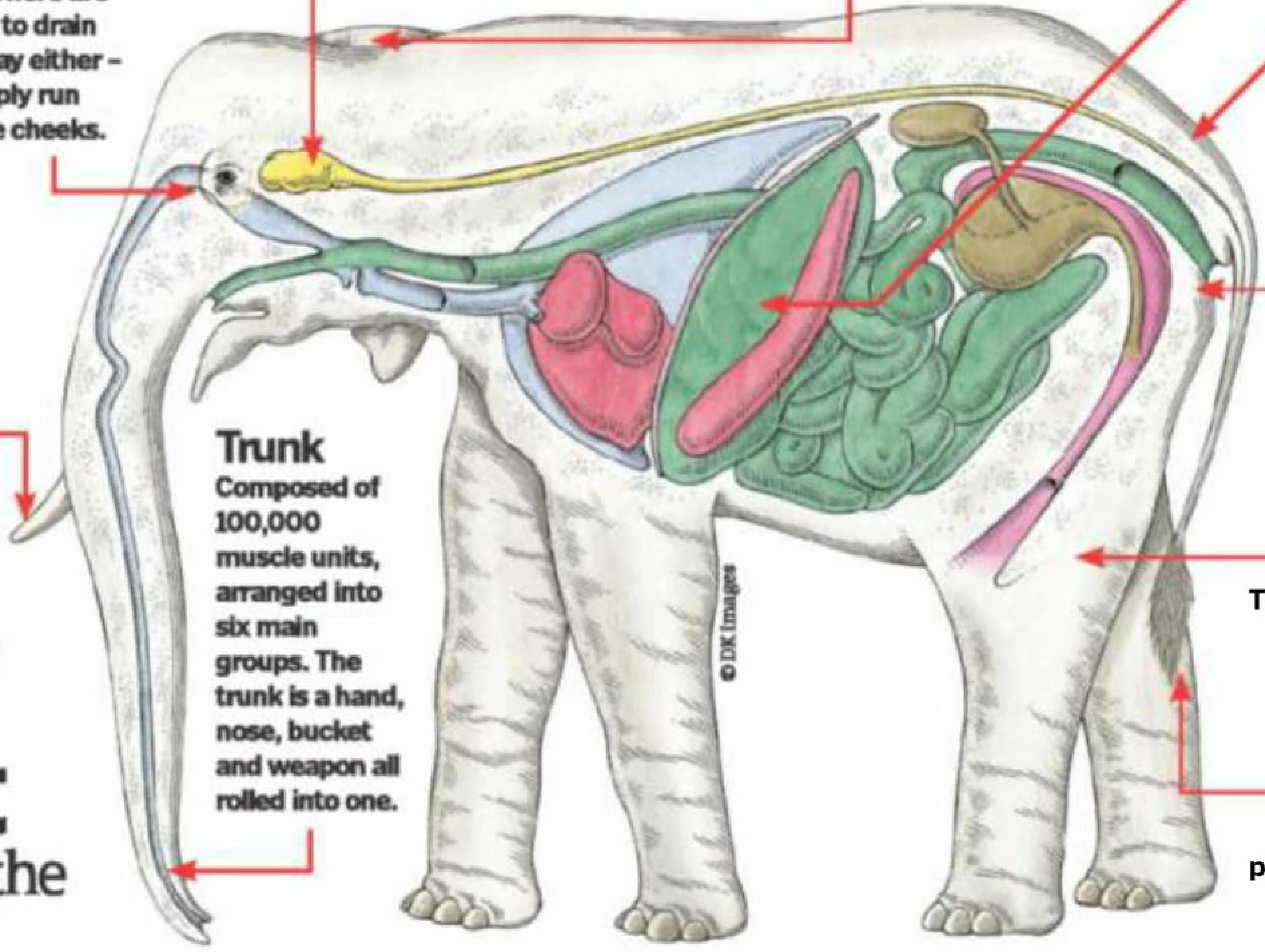
All the participants in the ancient Olympics, for the first several centuries of the competition, were aristocrats



Cool it! An elephant's ears are used for cooling and communication

Anatomy of an elephant

The physical attributes of the world's largest mammal



Eyes
Elephants don't see well at distances of more than 20 metres. There are no ducts to drain tears away either – they simply run down the cheeks.

Brain
At 5kg, their brain is the largest of any land animal. Like humans and dolphins, elephant brains have a highly convoluted neocortex, thought to be a sign of complex intelligence.

Ears
The large flapping ears are used for cooling and signalling. African elephants have ears up to three times larger than those of the Asian elephants.

Stomach
Elephants have an inefficient metabolism that doesn't properly digest cellulose. Consequently they have to eat 100-200kg of plant matter every day.

Hair
Although they look smooth-skinned, elephants actually have sparse hair all over their body, particularly on the head and back. Hair on the tail can be 1m long.

Skin
Elephant skin is 2.5cm thick on the back legs and trunk, but it's surprisingly delicate and elephants frequently coat themselves in mud to escape the sun.

Legs
The leg bones are very thick and a wide foot spreads the load. Even so the pressure under an elephant's foot is 3.5 times greater than a human's.

Tail
Elephants can produce 75kg of dung per day so an efficient swat to keep the flies away is essential. The tail looks small but it's over 1m long.

Tusks
Although they are useful for digging in the ground, stripping bark from trees and fighting, the ivory in the tusks is also the main reason that elephants are endangered.

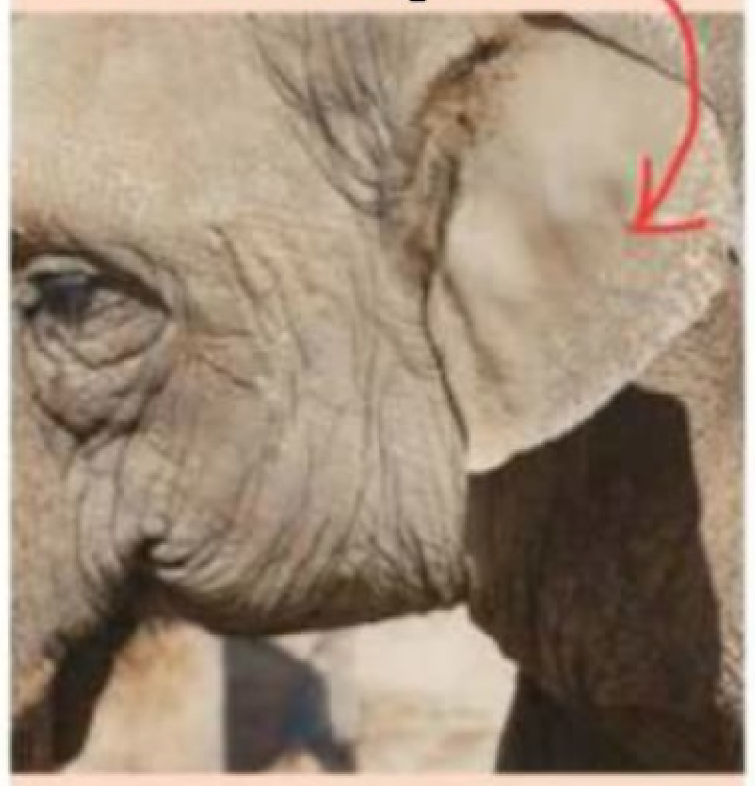
Trunk
Composed of 100,000 muscle units, arranged into six main groups. The trunk is a hand, nose, bucket and weapon all rolled into one.

Ears looking at you, kid

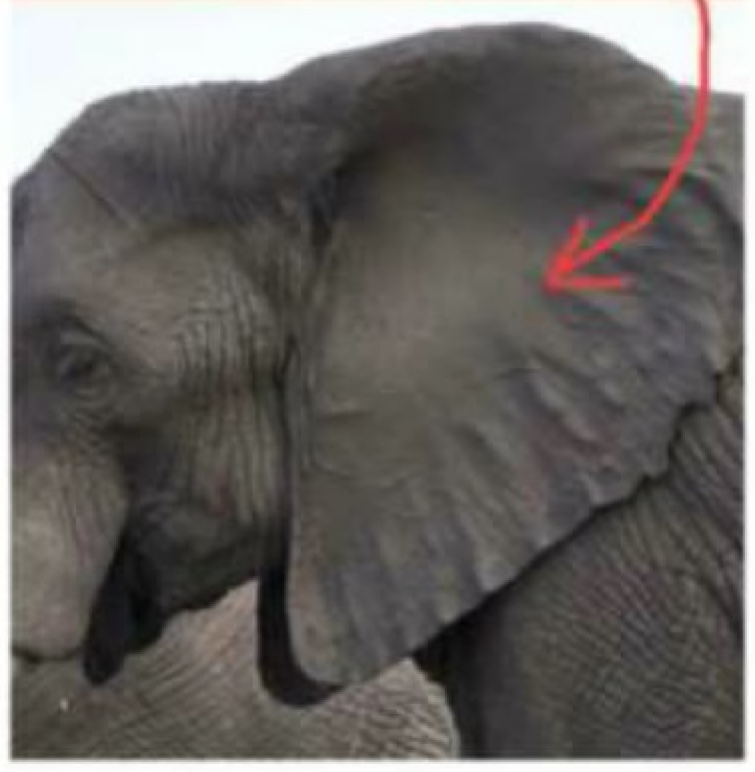
African elephants have enormous ears – 1.5 metres across for an adult. But those huge flaps aren't there to improve their hearing; they are air conditioning units. The skin covering the ears is paper-thin and richly supplied with blood vessels. By waving them back and forth, the elephant can dump body heat. Elephants have also evolved a secondary use for their ears; as a threat display. With his ears outstretched, an elephant appears even bigger, which might discourage attacks. Asian elephants have smaller ears because they generally live in cooler habitats.

Elephants hear over a much lower range of sound frequencies than we do, but this is mainly a function of their much larger size. Their sense of hearing is very acute but it isn't limited to their ears. Elephants also hear through the soles of their feet and the sides of the trunk.

Indian elephant



African elephant



Safety in numbers

Elephants have a highly matriarchal society. The herd is an extended family group of mothers, daughters, sisters and aunts with the oldest female in charge. Males leave the herd at an early age and wander alone or in temporary all-male groups, joining a herd only to compete for, and mate with, females during their oestrus cycle.

Herd members are all very aware of the various family relationships and will often renew contact with other related herds that have split away in the past. Non-breeding females will often act as nursemaids to young calves and at night the adults will surround the calves to protect them.

The longest pregnancy

Female elephants are fertile for just two days out of every four months. When the female oestrus cycle begins, she calls to advertise the fact and the males begin competing for dominance. The winner will mate with the female up to five times a day while she is fertile. Elephant testicles are kept inside the body, near the kidneys. The elephant's penis is almost as long as his trunk and equally manoeuvrable but despite this, the normal mounting position only just allows the penis to reach the flap covering the downward-facing vagina. Instead of penetrating her, the male sprays about half a pint of semen at the entrance.

Elephants will gestate for 22 months – longer than any other animal. When the calf is born it weighs around 115kg. It will be suckled by the mother for another 22 months after that. Most females only reproduce once every four to nine years.

Junior here was nearly two years in the making

Packing a trunk

The elephant's trunk has evolved from a fused nose and upper lip. There are two nostrils that remain separate all the way up the trunk. The African elephants have two finger-like projections on the end of the trunk, which can pick berries from a tree. The Asian elephant only has one projection and is limited to using it as a scoop.

Elephants have an excellent sense of smell and will often be seen pointing their trunks around to identify the source of a scent. But at the same time, the trunk is tough enough to be used for hoovering up mud and dust to squirt over the elephant's body as a protection from the Sun. Elephants also suck up water through their trunk but it's more a syringe than a straw because they always squirt the water into their mouth before swallowing.

A case of 'trunk and disorderly?'

Head to Head LARGEST MAMMALS

1. Blue whale
Not only the biggest mammal but also the biggest animal ever to have existed. In fact, whales could occupy all three spaces here.

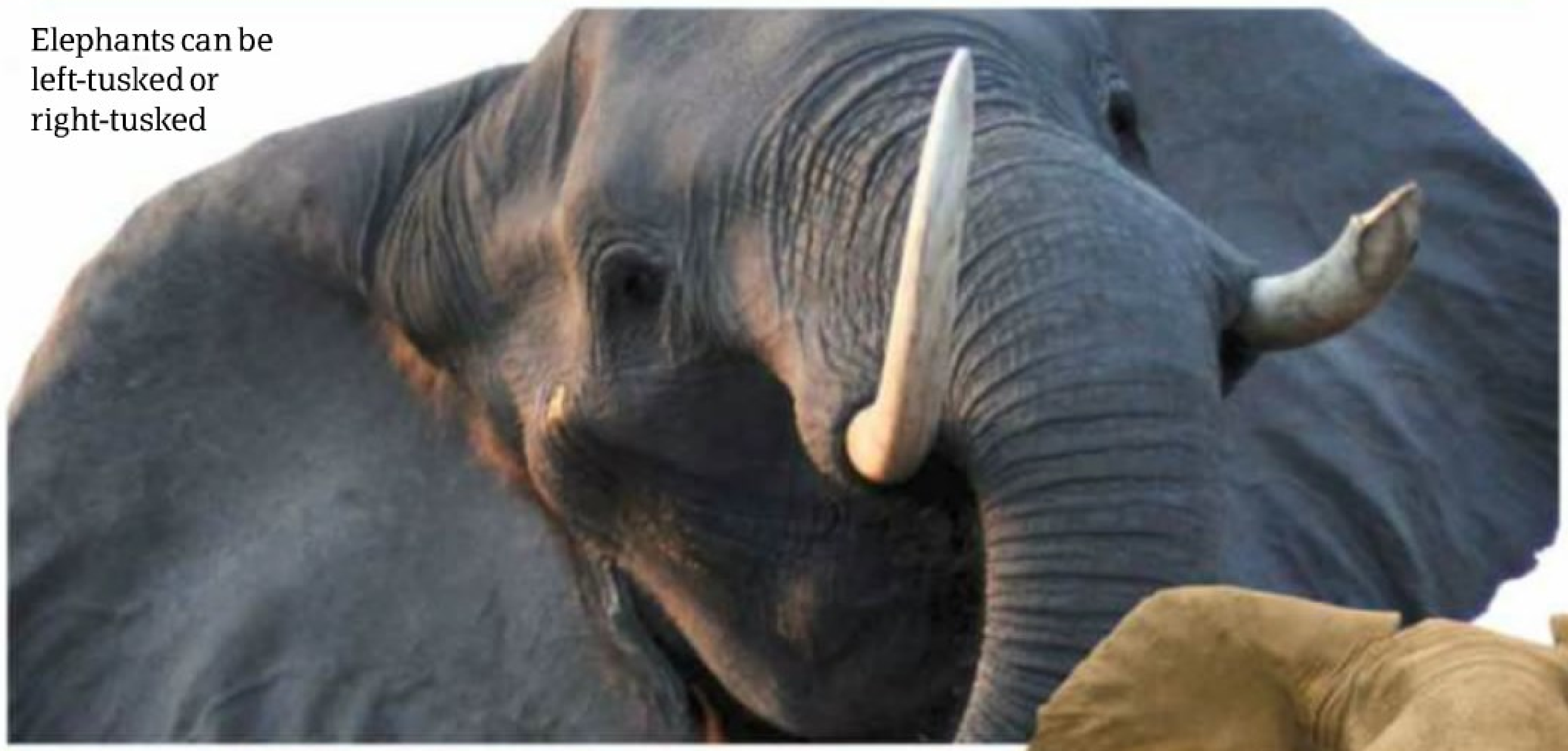
2. Elephant
The largest land mammal, elephants would occupy both second and third place if we counted African and Indian species as separate.

3. Rhino
The horny rhino comes in as the second largest land mammal with the hippo coming in a very close third. Rhinos are native to Africa and Asia.

DID YOU KNOW? A prehistoric elephant species that lived in Crete 2 million years ago was only the size of a pig

Tusks

In most mammals, the largest teeth are the canines but elephant tusks are formed from the second upper incisors. Both male and female African elephants have tusks but female Asian elephants do not. The tusks grow throughout the elephant's life at a rate of about 18cm per year. The largest African elephant tusks can reach 3m long. One third of the tusk is embedded in the skull. This root is full of blood vessels and nerves that supply the growing tusk. The outer two-thirds is bony dentine covered in a layer of a mineral called apatite, which is mainly calcium phosphate. This layer is the ivory. African elephants use their tusks to dig for water and roots whereas Asian elephants use the tusks mainly for dominance displays between males.



Elephants can be left-tusked or right-tusked

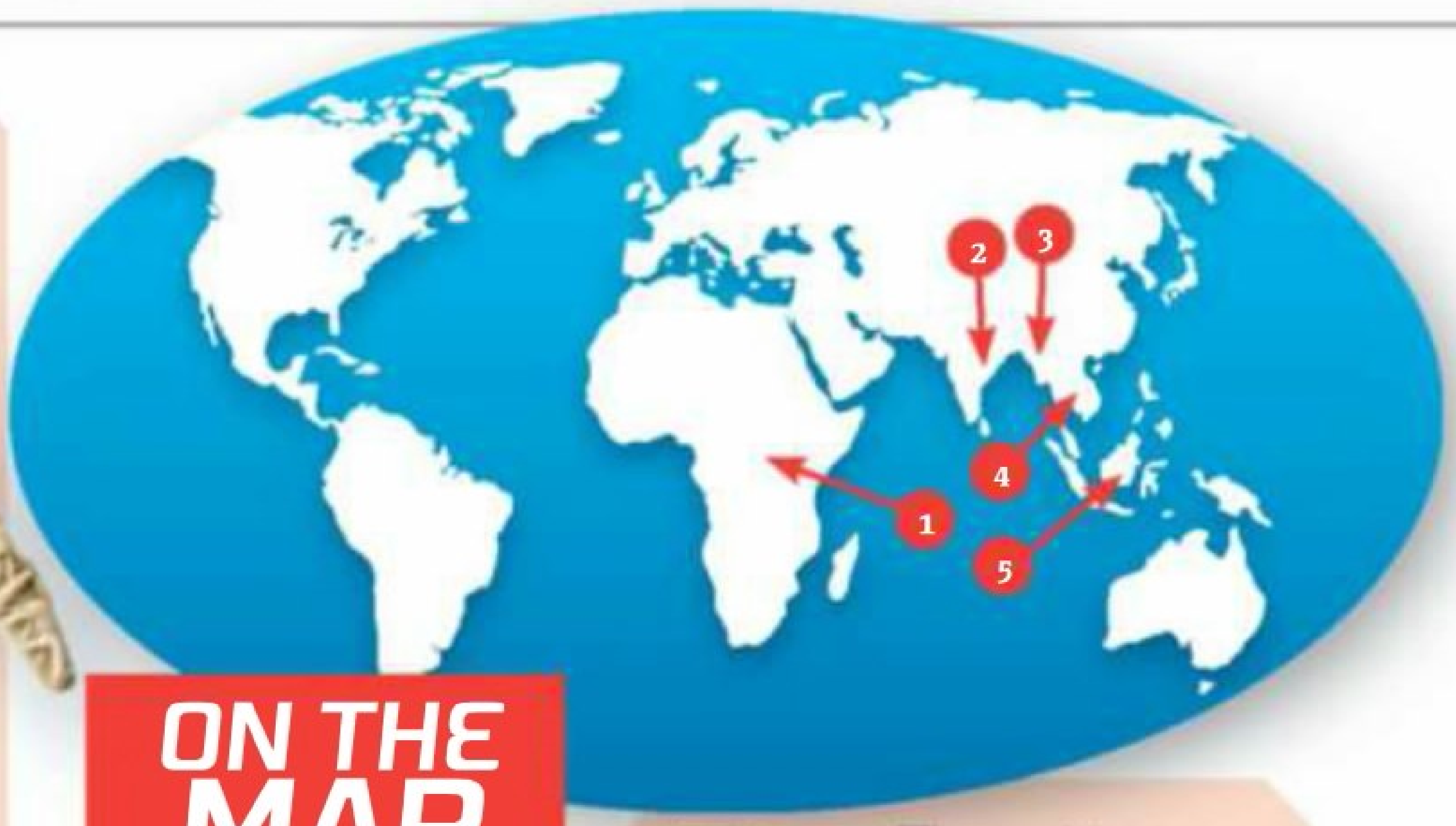
"Does grey make my bum look big?"

He looks ready to take someone to tusk

Safe from harm?

One of the main reasons elephants have evolved to be so large is to protect themselves from predators. Lions and occasionally hyenas may successfully kill a young elephant, if it can be separated from the herd, but an adult elephant is virtually invulnerable.

Tusks, however, are their greatest vulnerability. The ivory in the tusks of a large African male can be worth more than £5,000 to poachers and an estimated 20,000 elephants a year are illegally killed for their ivory. Periodic legal culls and one-off sales of old ivory have made it much harder to police the illegal ivory trade. The evolutionary pressure from poaching is such that a once-rare genetic mutation, which results in tuskless elephants, is spreading rapidly. As many as ten per cent of Asian elephants in China may now be tuskless.



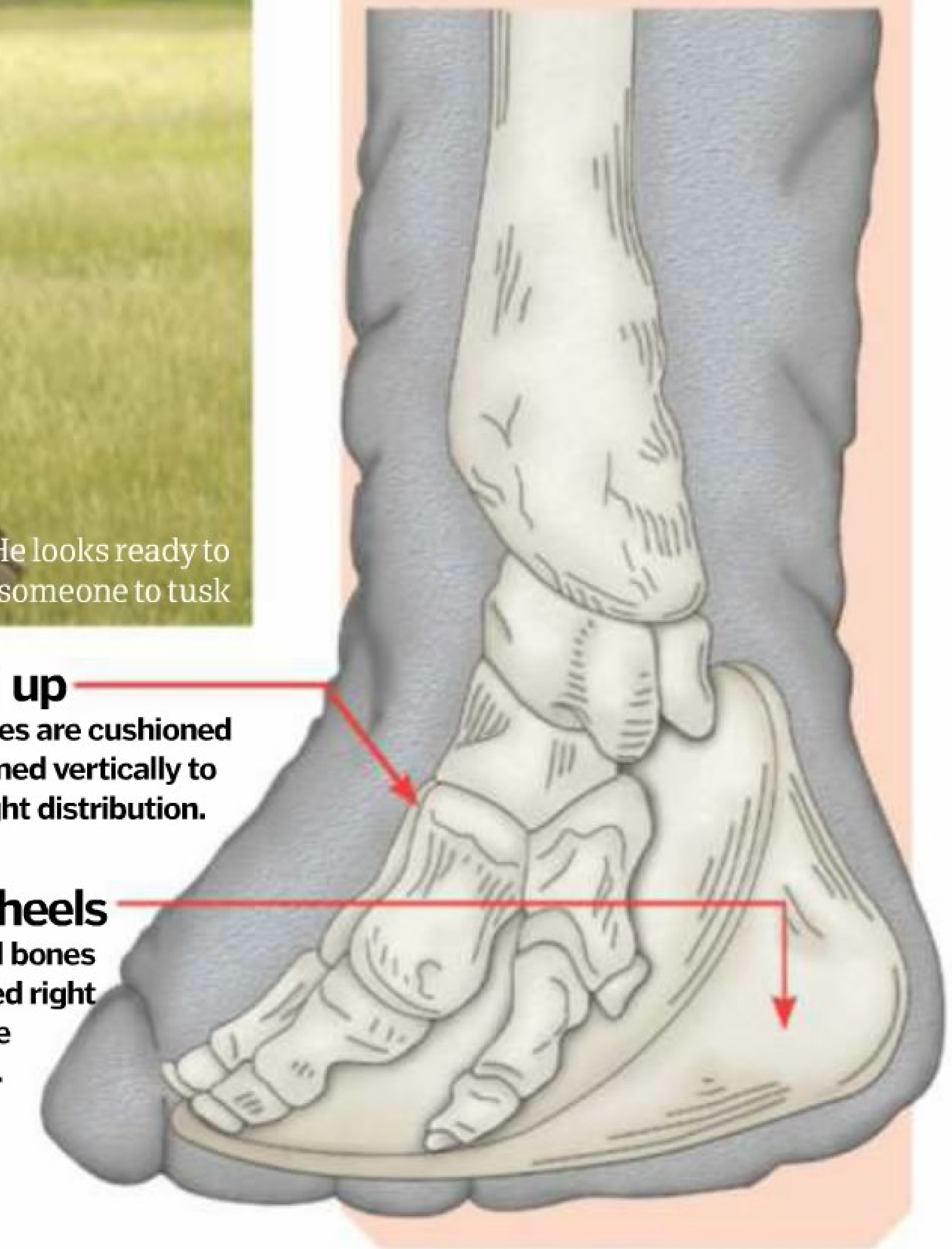
ON THE MAP

Where do elephants live?

African elephants are found in scattered populations across all of sub-Saharan African (1) countries, apart from Somalia and Madagascar. The Asian elephant is found mainly in India (2), with smaller populations extending through Burma (3), Thailand (4) and Borneo (5).

Dainty steps

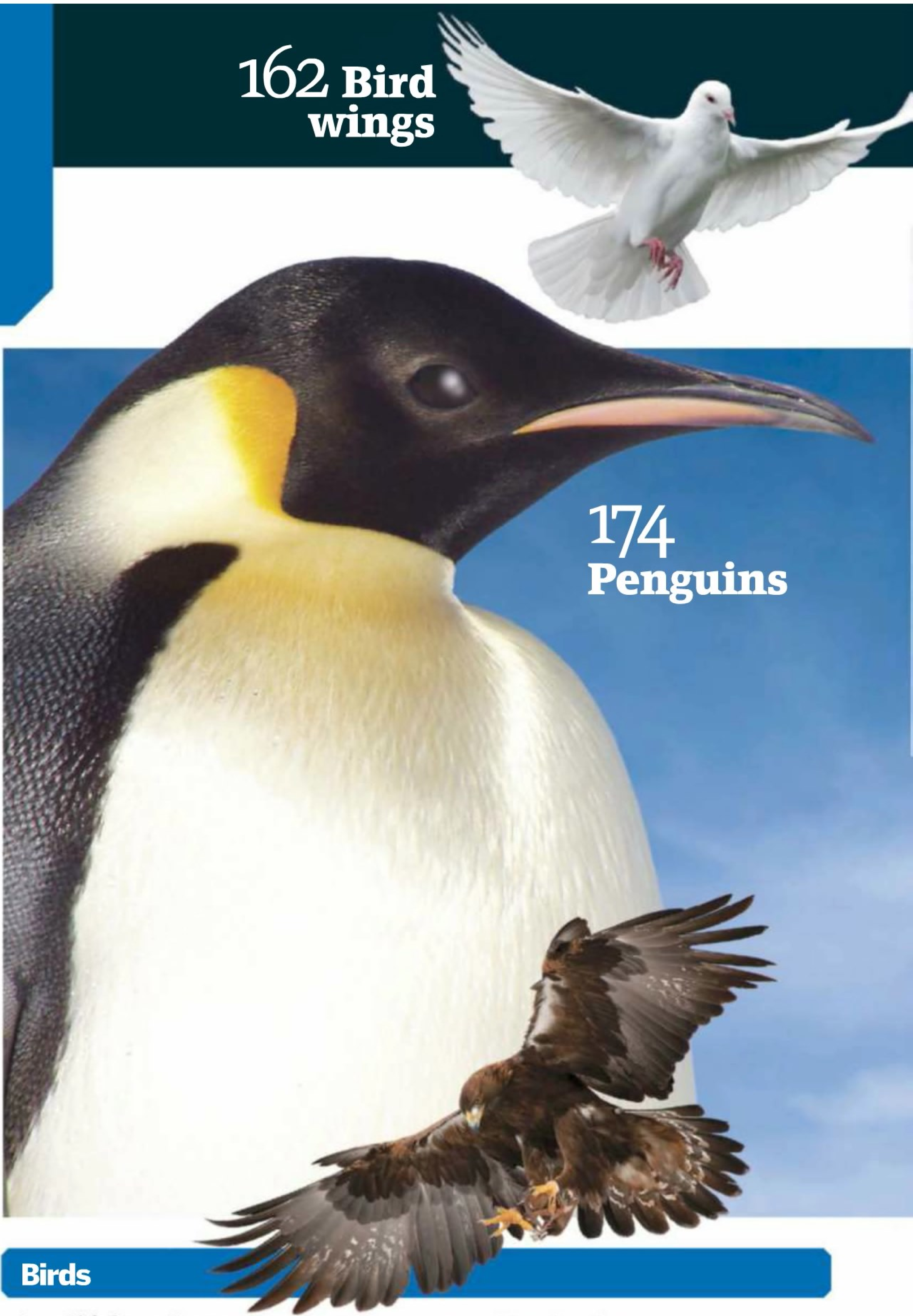
An elephant is essentially walking in high-heeled shoes, because the heel bones are raised right up inside the foot and rest on a thick pad of fatty cartilage. This cushions the bones and aligns them more vertically so that the vast weight of the elephant rests directly over the pillar-like legs. African elephants have four toenails at the front and three on the hind legs. Asian elephants have five at the front and four at the back. But these 'toenails' are actually just hardened skin patches that aren't attached to the toe bones at all. Buried inside, elephants have five toes on each foot.

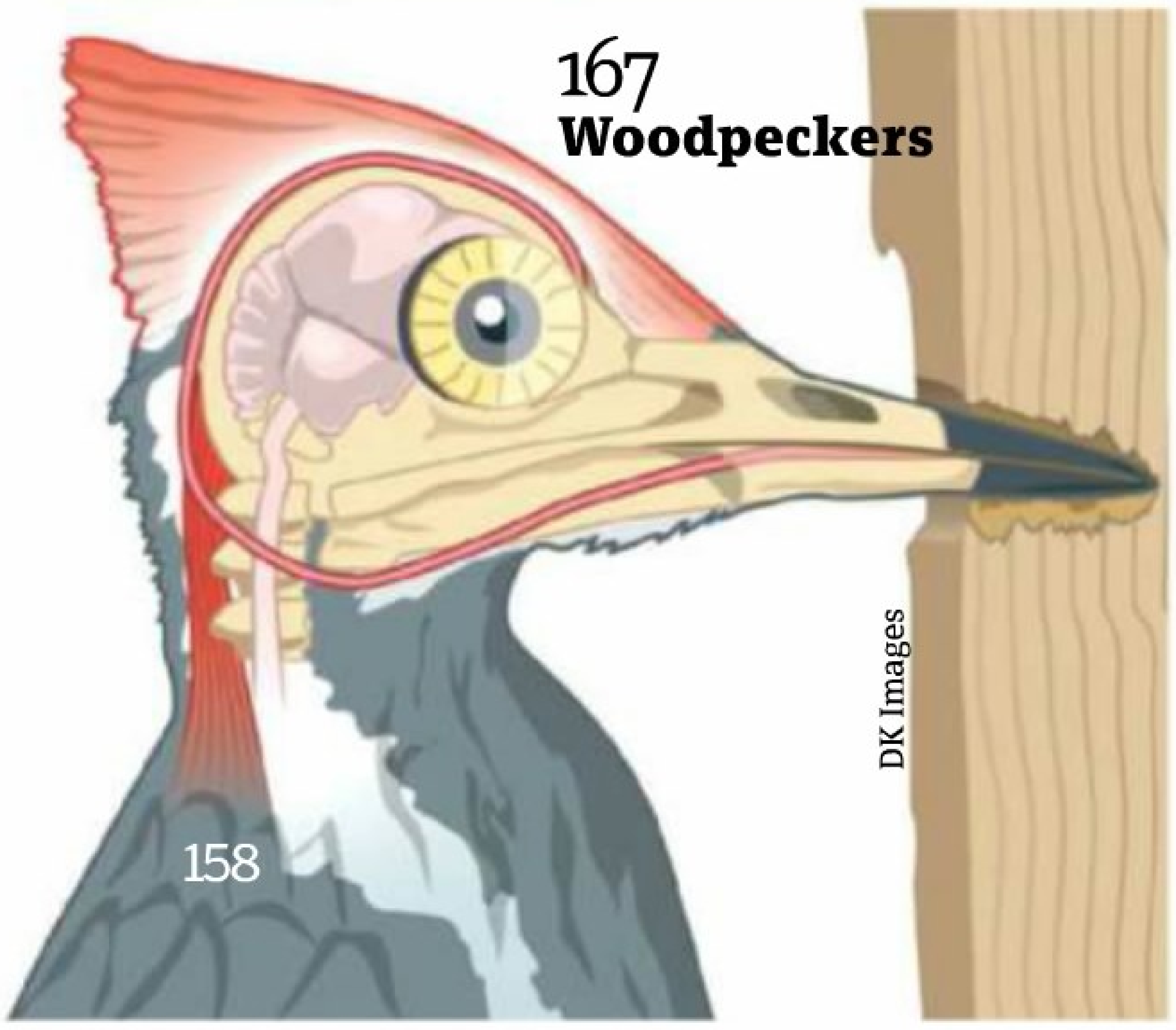


Lined up
The bones are cushioned and aligned vertically to aid weight distribution.

High heels
The heel bones are raised right up inside the foot.

BIRDS





DK Images

Birds

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From oocyte to omelette

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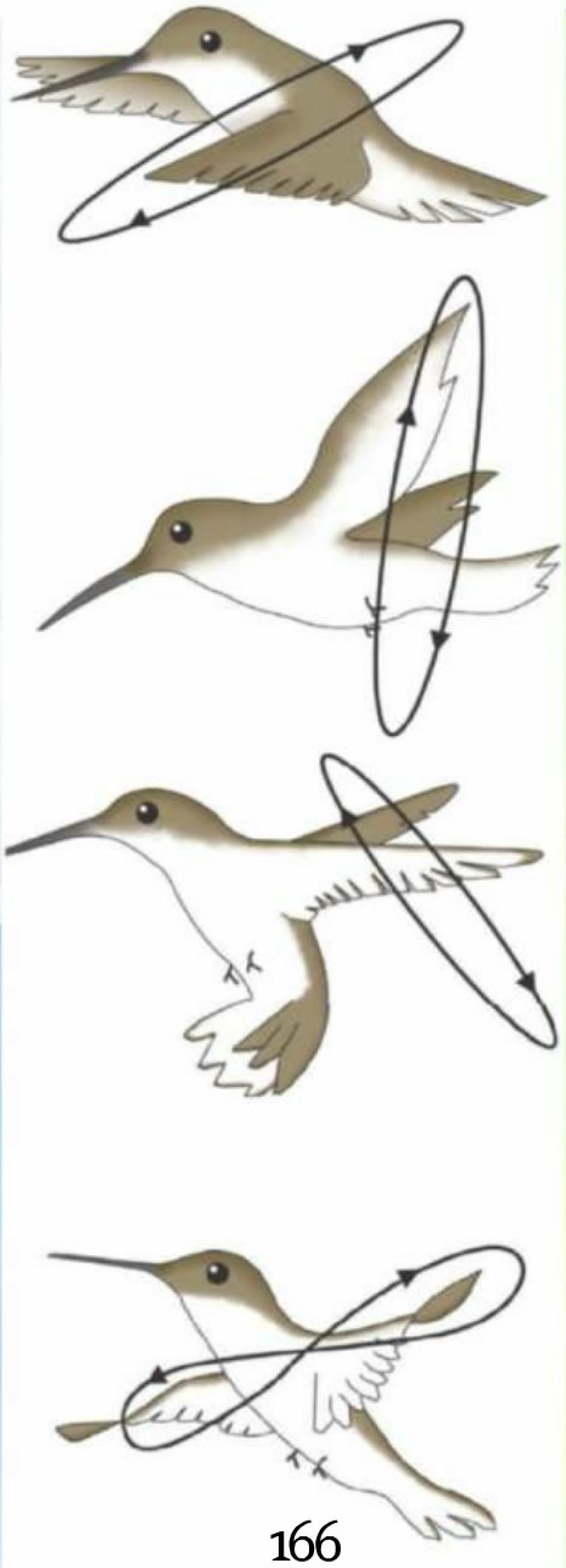

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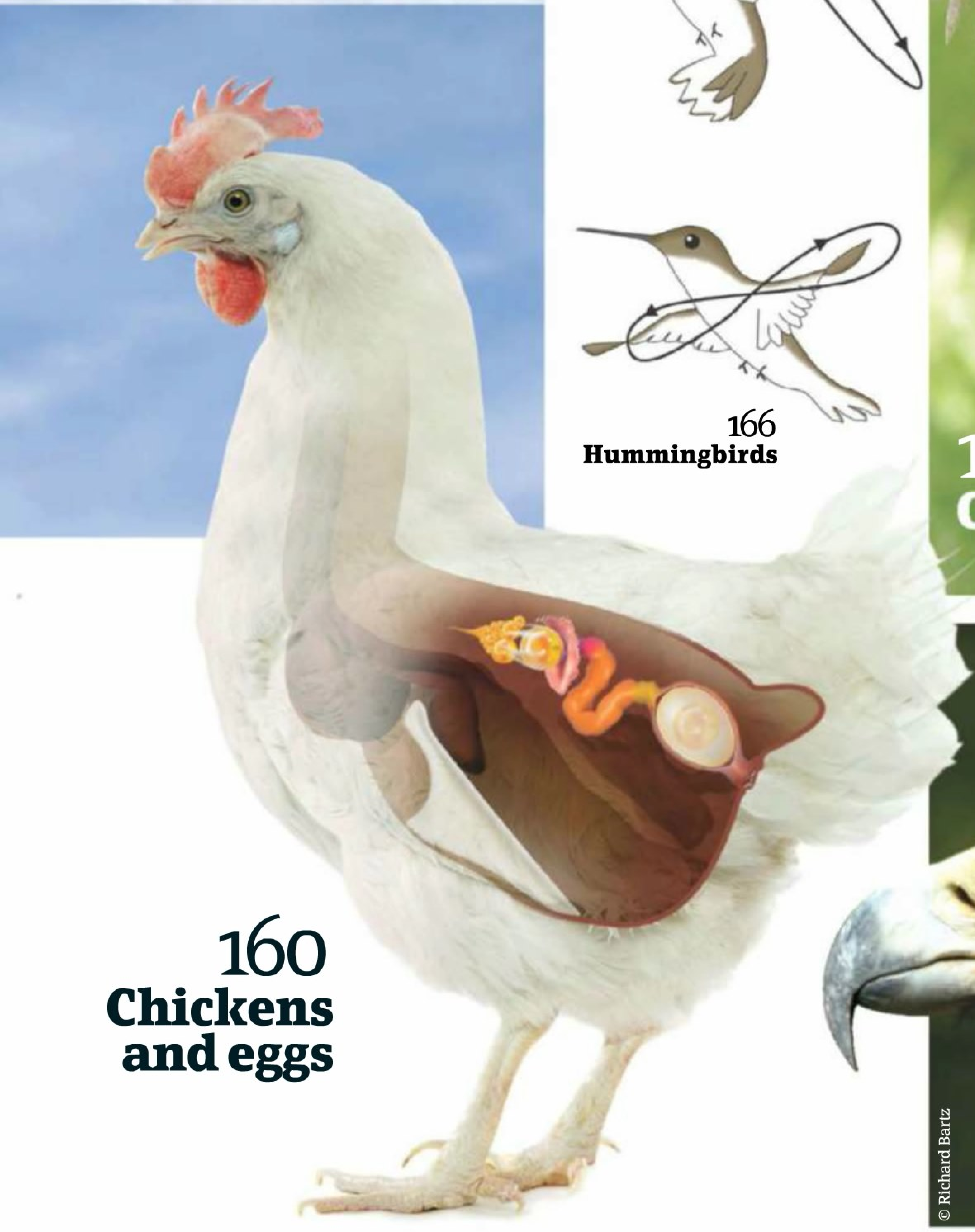

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Chickens and eggs

Golden eagles
172

© Richard Bartz

Chicks need to rest for several minutes after hatching to regain their strength

How do chickens lay eggs?

The debate over which came first – the chicken or the egg – still rages. However, we can tell you how a chick emerges from an egg…

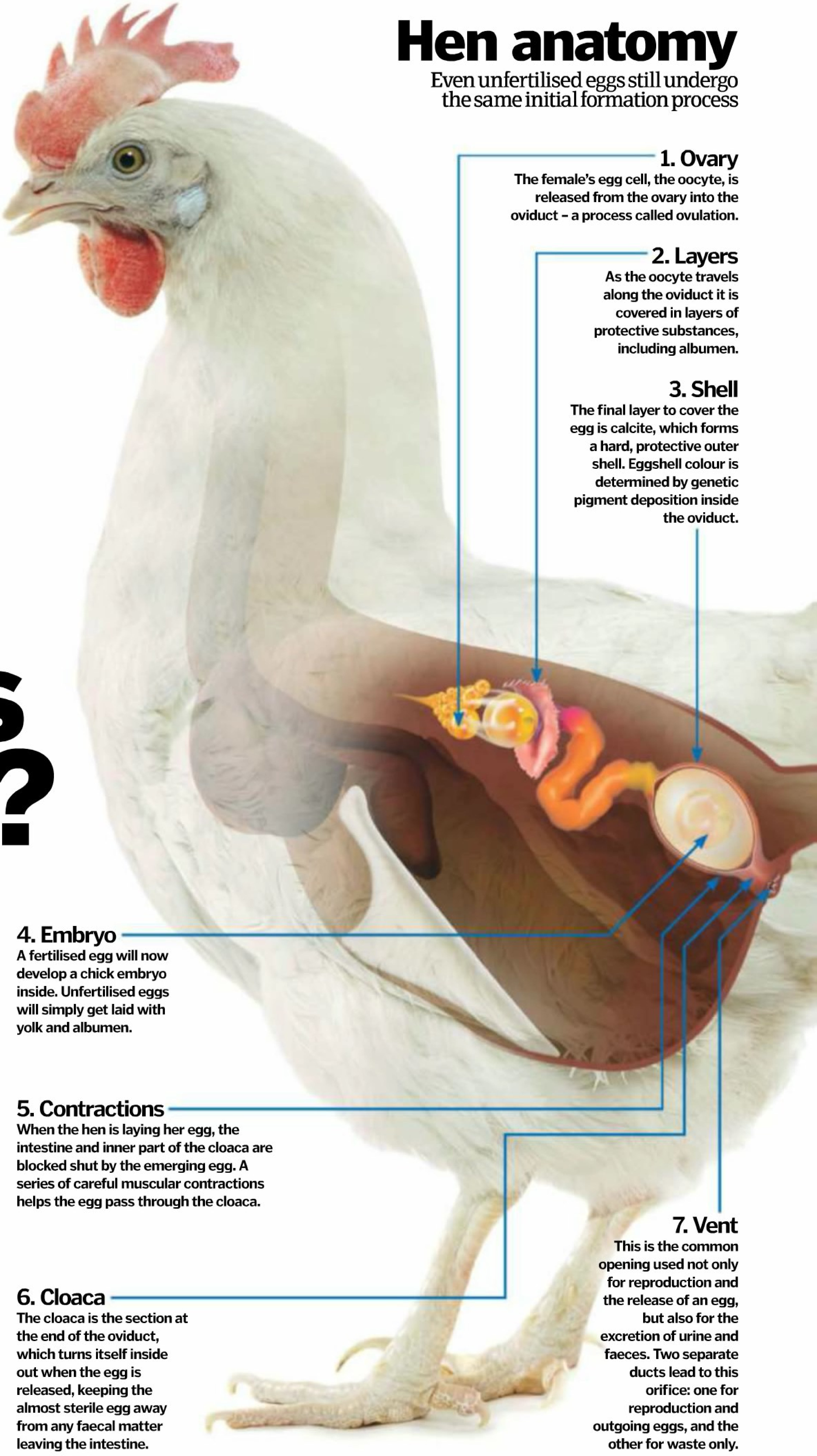
Hens lay no more than one egg per day as the process of laying an egg is governed by the presence of sunlight. The lack of natural light during the winter months means that even fewer eggs are laid during this time of the year. Humans can, however, 'trick' chickens into laying despite the limited sunlight by adding artificial light (such as a light bulb) to the coop.

The laying process starts when light entering the hen's eye activates a photosensitive gland (the pineal gland) positioned nearby. Once stimulated, this gland triggers a process that leads to the release of an egg, or oocyte, from the hen's ovary. An egg can still be laid whether or not it has been fertilised by a male, but only fertilised eggs can develop into chicks.

The orifice through which the egg leaves the hen is called the vent. Though this hole also forms the outlet for waste by-products (ie urine and faeces), there is a valve called the cloaca which separates the oviduct from the intestine.

Hen anatomy

Even unfertilised eggs still undergo the same initial formation process



1. Ovary
The female's egg cell, the oocyte, is released from the ovary into the oviduct – a process called ovulation.

2. Layers
As the oocyte travels along the oviduct it is covered in layers of protective substances, including albumen.

3. Shell
The final layer to cover the egg is calcite, which forms a hard, protective outer shell. Eggshell colour is determined by genetic pigment deposition inside the oviduct.

4. Embryo
A fertilised egg will now develop a chick embryo inside. Unfertilised eggs will simply get laid with yolk and albumen.

5. Contractions
When the hen is laying her egg, the intestine and inner part of the cloaca are blocked shut by the emerging egg. A series of careful muscular contractions helps the egg pass through the cloaca.

6. Cloaca
The cloaca is the section at the end of the oviduct, which turns itself inside out when the egg is released, keeping the almost sterile egg away from any faecal matter leaving the intestine.

7. Vent
This is the common opening used not only for reproduction and the release of an egg, but also for the excretion of urine and faeces. Two separate ducts lead to this orifice: one for reproduction and outgoing eggs, and the other for waste only.

Head to Head
THE SCIENCE OF COOKING EGGS

1. HEATING

Fried egg
Egg white contains mainly water and protein. Heat excites the proteins and this breaks down bonds, enabling the proteins to bind with one another.

2. BEATING

Meringue
Just like heating causes bonding, so does adding air. Whisking exposes one end of the molecules to air and the other to water causing the proteins to align and fuse.

3. MIXING

Mayonnaise
Oil and water don't mix, due to differing polarities. However, an emulsifier like egg yolk attaches one end of an egg's protein strand to water and the other end to the oil, binding the two.

DID YOU KNOW? *The chicken is now believed to be the closest living relative of the T-rex*

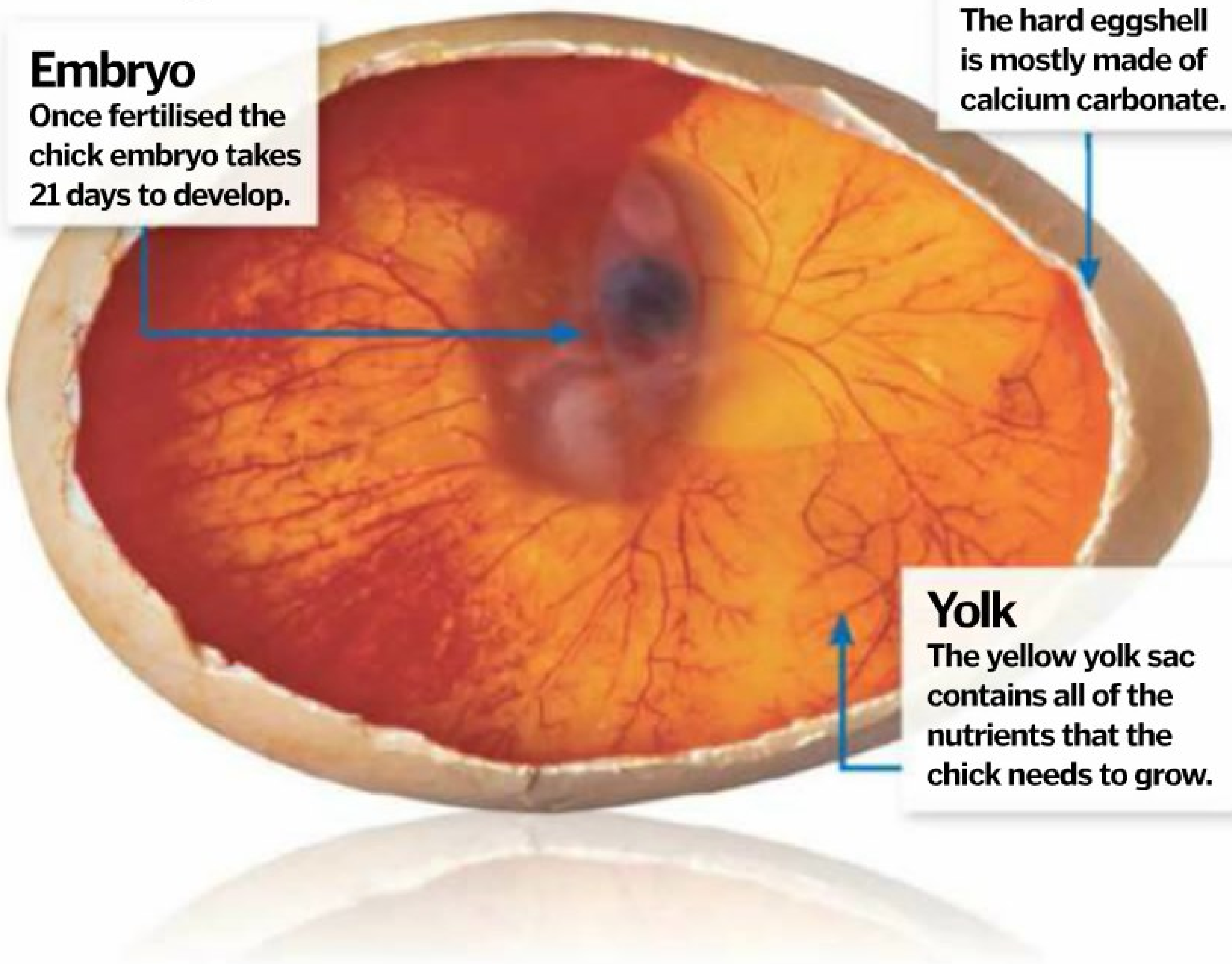
In a natural environment, chickens live in a flock and take a communal approach to caring for eggs

Feeling broody?

A hen will keep laying around one egg per day until she has a dozen eggs – also known as a clutch. If the eggs are collected by humans each day, however, the hen will continue to lay eggs in an effort to produce a clutch of 12. Once an egg has been laid, the hen will leave the nest, causing the embryo to cool and suspending its development. As long as the nest temperature stays warm enough, an embryo can remain suspended for up to two weeks until the hen has managed to lay a full clutch. Once she has produced a clutch of eggs the hen will stop laying and start brooding, which involves sitting on the eggs for three weeks while the embryos develop. This means the eggs should all hatch at the same time.

Inside the egg

What goes on under the shell?



Embryo
Once fertilised the chick embryo takes 21 days to develop.

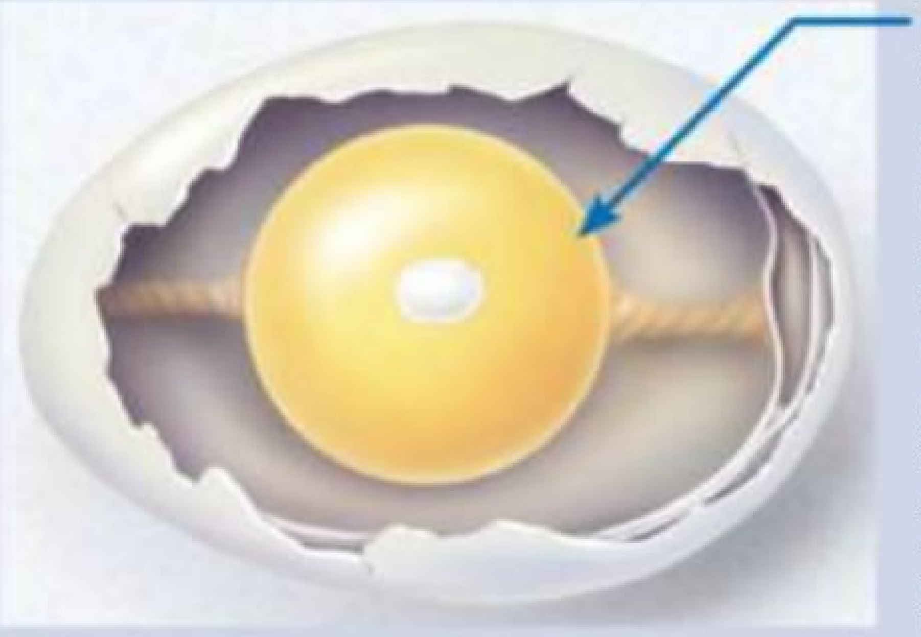
Shell
The hard eggshell is mostly made of calcium carbonate.

Yolk
The yellow yolk sac contains all of the nutrients that the chick needs to grow.

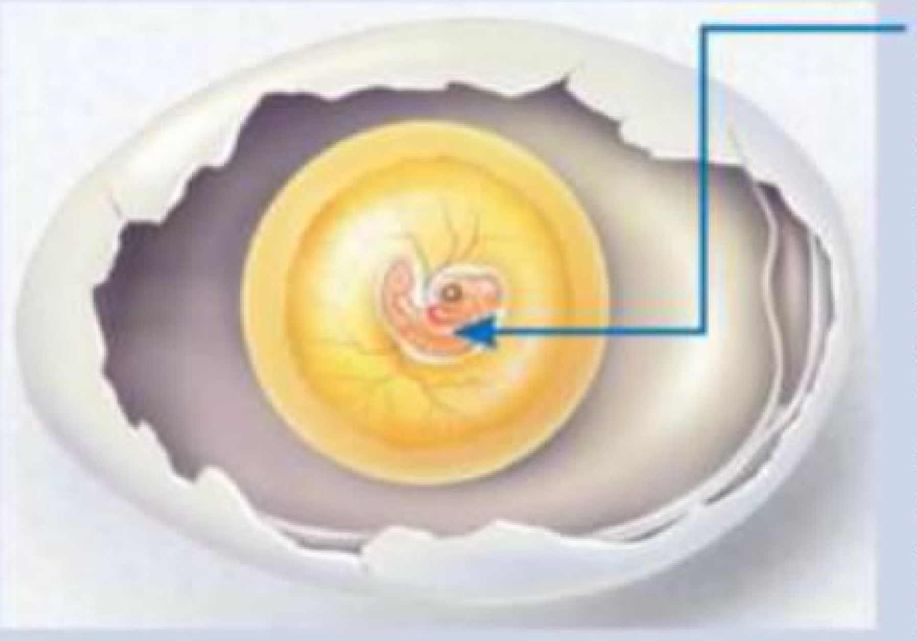
Embryo development

How a fertilised yolk transforms into a chick

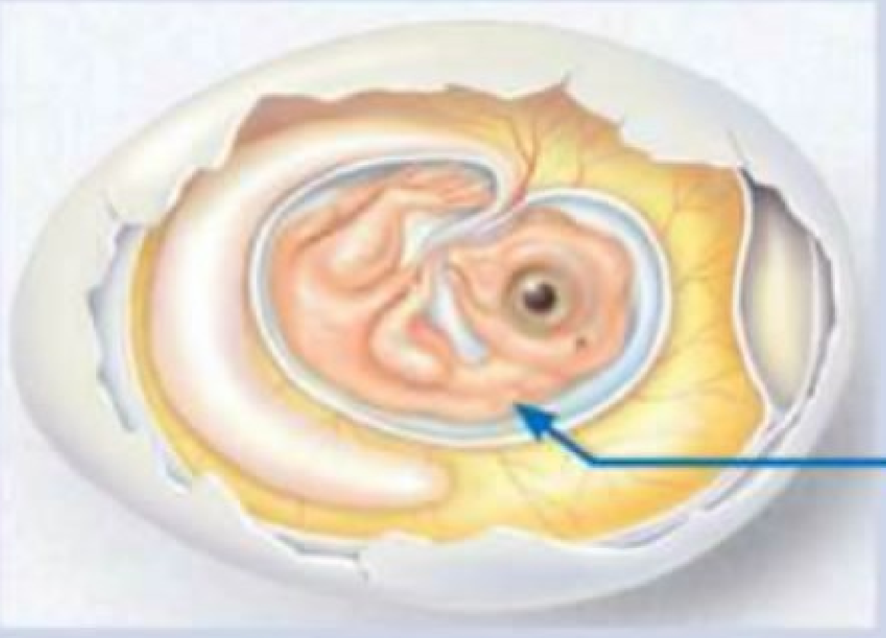
The chick starts out as a single cell that divides and forms a hollow disc on the surface of the yolk. This yolk is then released into a spiralling oviduct tube. As it travels down the oviduct it builds up a number of layers, including a vitelline membrane directly surrounding the yolk, and two layers of viscous white albumen divided by a structural fibrous layer. Lower in the oviduct tube the eggshell layer develops around the yolk, protecting it and giving it form. When the egg is expelled from the body so begins the following 21-day period of embryonic development…



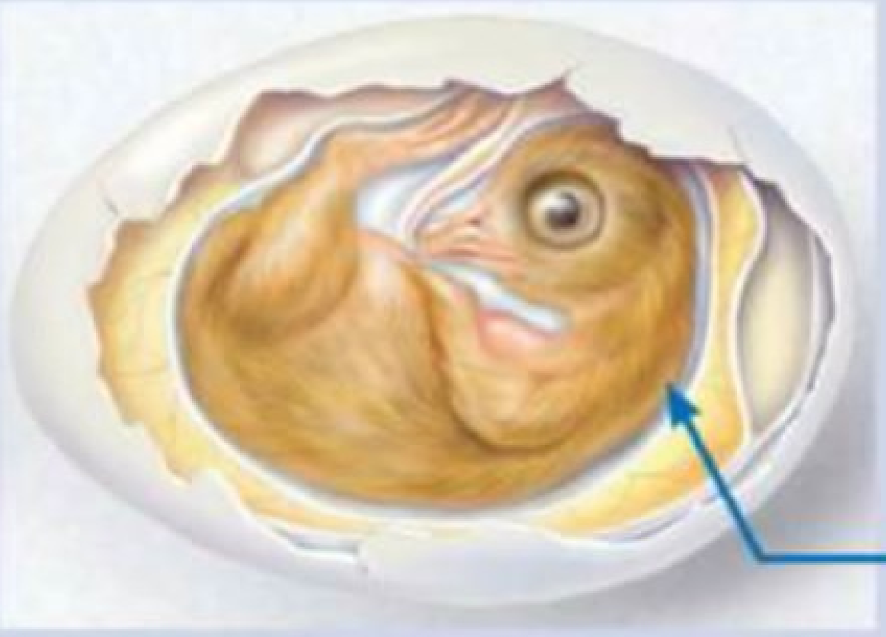
DAY 1 Yolk
The fertilised yolk contains all the nutrients needed to sustain a developing embryo – the darker the yolk the better. By the time a fertilised egg is laid, many cells have already started to divide in the germinal disc on the surface of the yolk. A structure called a chalaza made of albumen located inside the egg holds the yolk in place, anchoring it to either end of the shell and protecting it. Over time the chalaza gets twisted as the yolk moves around.



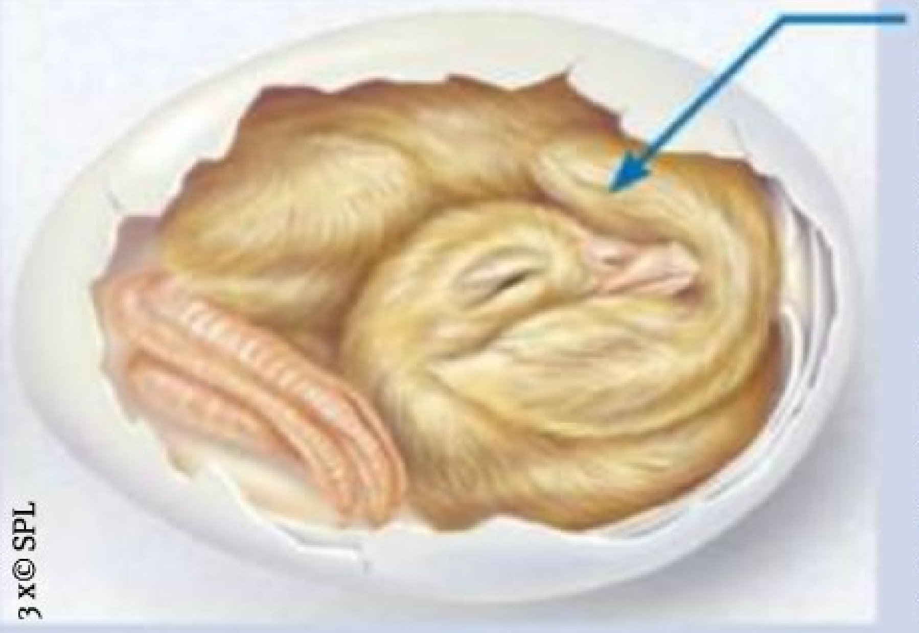
DAY 4 Heart
After a couple of days the heart will have formed and begun to beat independently. At this stage the head, eyes and even the beginnings of its legs will have begun to form, and by day four the embryo's reproductive organs will start to develop. The thin membrane separating the albumen from the eggshell grows as the contents of the egg shrinks, creating a tiny pocket of air. This air space will eventually enable the chick to start to breathe.



DAY 10 Skeleton
After ten days the embryo will still be featherless but it will start to draw calcium from the shell in order to grow its tiny skeleton, enabling the bones of the legs and spine to develop. The claws and beak will also begin to form.



DAY 16 Preparing to hatch
The leg and wing bones will become increasingly advanced and strong. Internal organs are now almost fully developed too. By now the beak will also be upturned towards the pocket of air inside the shell, ready to break through the soft inner membrane and take its first breath.

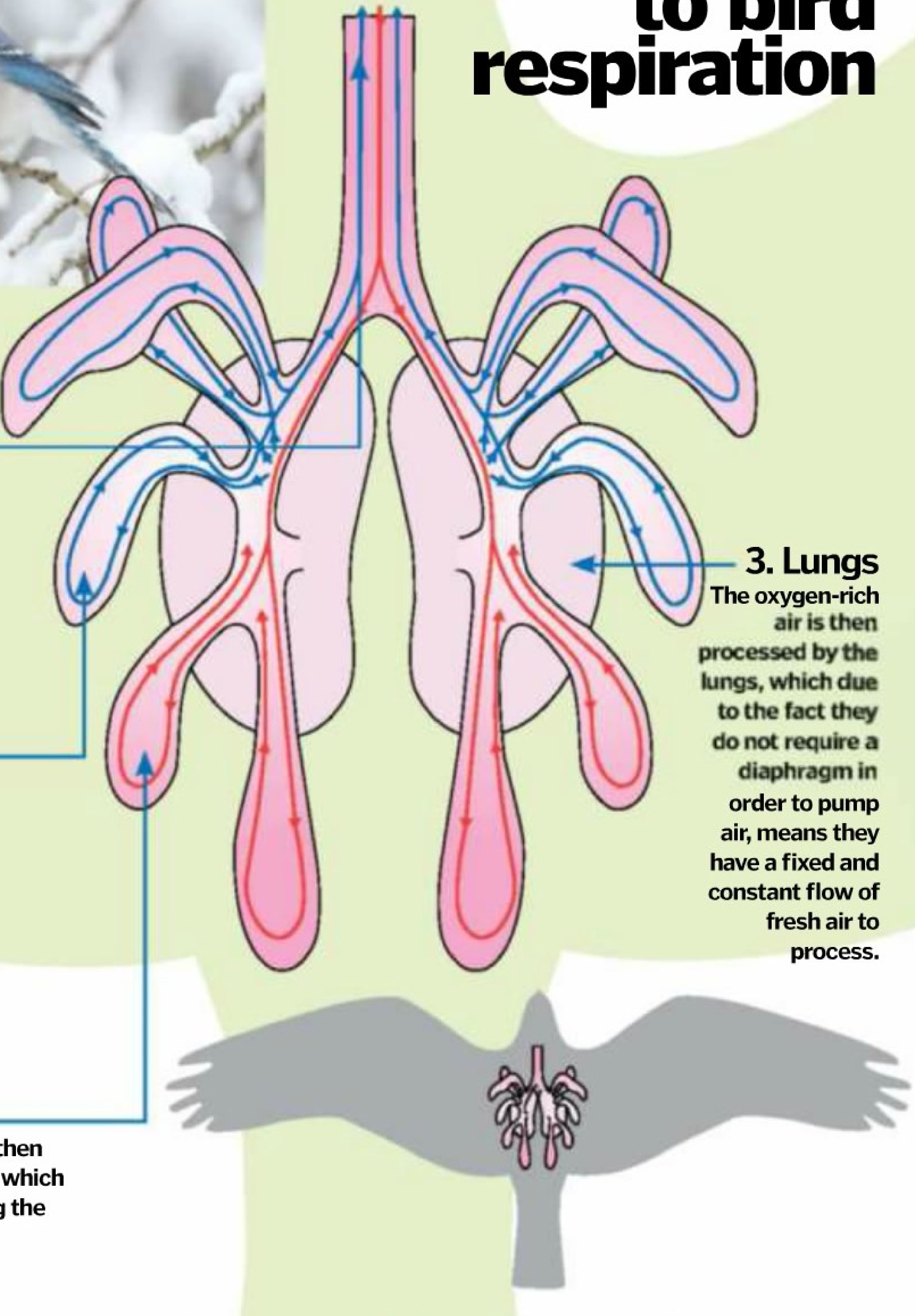


DAY 20 Breakthrough
Between day 16 and hatching, the chick's beak will have penetrated the inner membrane to access the air inside the shell and the lungs will have begun to function. The yolk sac has now been absorbed into the chick's body cavity. The chick pecks at the outer shell using a horny projection on its beak called the egg tooth. The second stage involves twisting its body and chipping away at the shell, until it can push the top of the shell off with its head.

3 x © SPL

© Mdf

A guide to bird respiration



1. Throat
Air passes into the bird normally through the trachea during flight.

2. Rear air sacs
The gathered oxygen-rich air then enters the bird's rear air sacs, which in-turn act as bellows, filtering the air into the lungs.

3. Lungs
The oxygen-rich air is then processed by the lungs, which due to the fact they do not require a diaphragm in order to pump air, means they have a fixed and constant flow of fresh air to process.

4. Forward air sacs
Once the oxygen has been processed by the lungs, the stale air enters the forward air sacs and is then exhaled through the trachea.

How do birds breathe?

Forced to evolve due to an exceedingly high metabolic rate and oxygen demand, birds sport an efficient and refined respiratory system

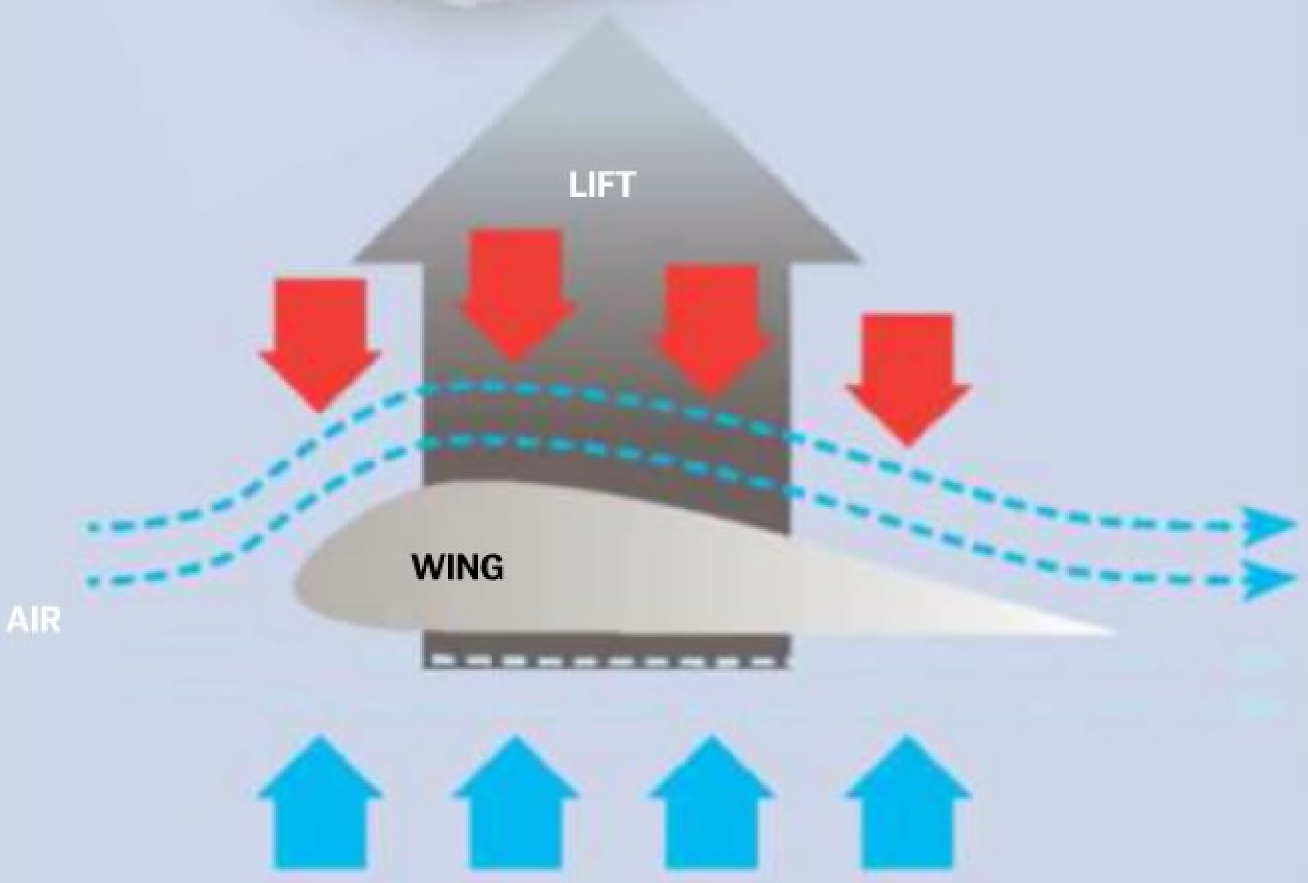
Birds breathe by partnering a pair of lungs without a diaphragm with a system of internal air sacs that act as bellows. The reason for this is due to the bird's high metabolic rate and oxygen demand when flying, constantly needing a stream of oxygen-rich air to process in order to remain active.

This would not be possible with the bi-directional lungs of mammals as oxygen-rich air is mixed with oxygen-deficient stale air during the breathing process, reducing the amount of oxygen that can be processed in the lungs at any one time.

However, with the unidirectional flow that is made possible by separating the pump part of respiration (the sacs) with the absorption part (the lungs), a constant oxygen-rich stream can be maintained. Avian lungs do not process oxygen with alveoli as mammal lungs do, but absorb it through honeycomb-structured passages – parabronchi – into air vesicles, which themselves contain oxygen/carbon dioxide trading capillaries.

Birds' wings explained

The bird wing is nothing short of a scientific marvel



Some birds can live their entire lives aloft, even soaring while sleeping. Others migrate thousands of kilometres.

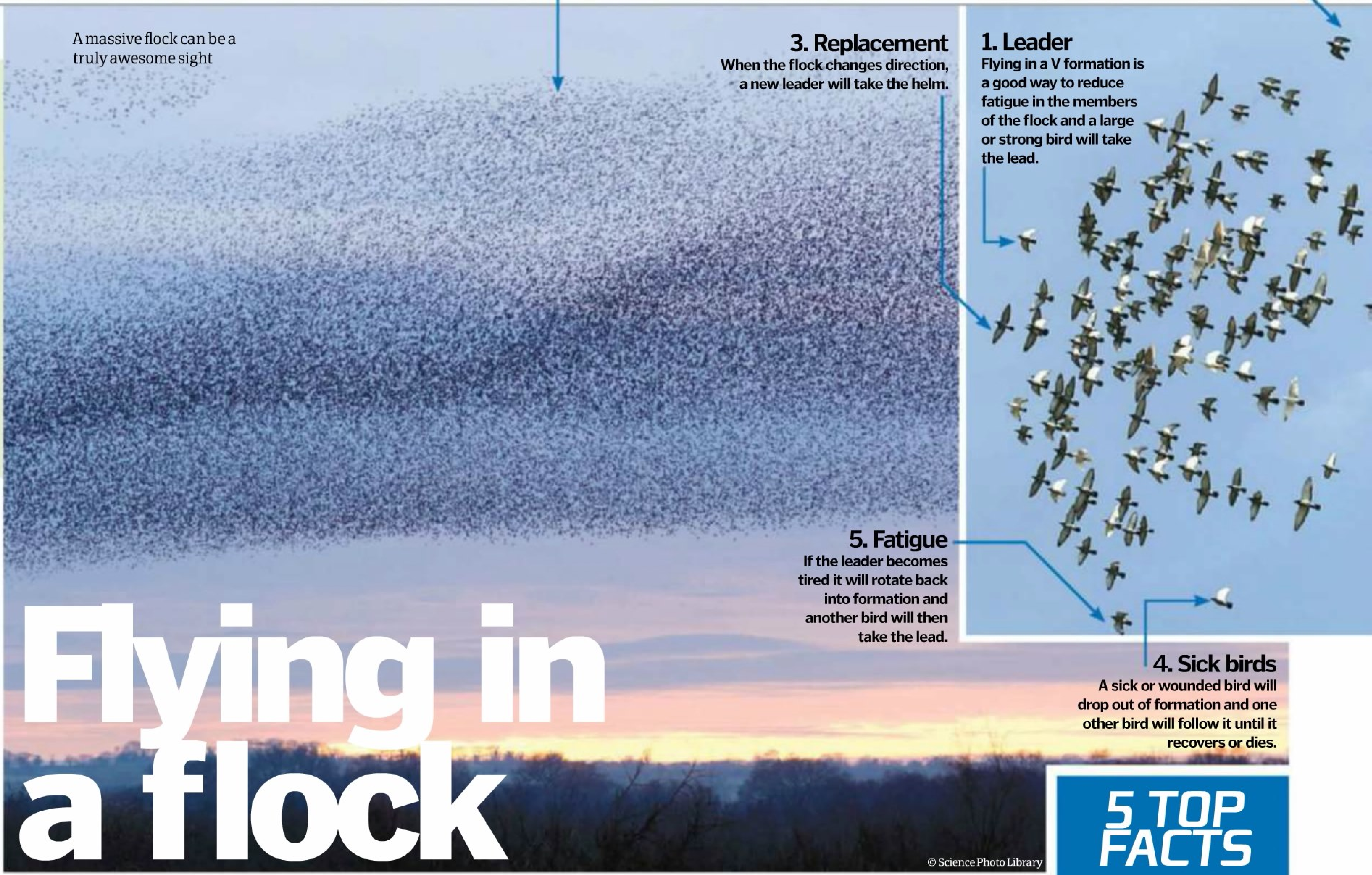
The real miracle is the wing itself, a singular feat of evolutionary engineering.

When outstretched for gliding, bird wings form a perfect aerofoil, a surface that is curved on top and flat on the bottom. According to Bernoulli's principle, air travels faster across the curved upper surface, lowering air pressure above the wing and generating lift.

Aeroplane wings require separate engines, but bird wings provide both lift and thrust. During flapping flight, birds are essentially 'rowing' through the air, pushing down and back powered by two thick layers of pectoral muscles.

Wing feathers grow in separate sections that shift position and overlap to provide a smooth curved surface for maximum lift. On an upstroke, contoured flight feathers collapse along a rigid shaft, minimising the resistance, then expand on the downstroke, maximising thrust.

Flying in a flock



A massive flock can be a truly awesome sight

1. Leader
Flying in a V formation is a good way to reduce fatigue in the members of the flock and a large or strong bird will take the lead.

2. Followers
Each bird will benefit from the updraft created by the flapping of the bird in front's wings (which creates currents of circulating air), generating lift for the birds behind to take advantage of.

3. Replacement
When the flock changes direction, a new leader will take the helm.

4. Sick birds
A sick or wounded bird will drop out of formation and one other bird will follow it until it recovers or dies.

5. Fatigue
If the leader becomes tired it will rotate back into formation and another bird will then take the lead.

6. Resistance
If a bird falls out of formation it will notice the extra resistance and immediately get back in line.

© Science Photo Library

How and why do birds flock together, and why don't they bump into each other?

Watching as a massive collection of birds float across the sky like an unpredictable wave, it's difficult to comprehend how birds can fly in formation without the aid of the high-tech location equipment used by aerobatic teams like the Red Arrows. Such patterns may look like the result of extrasensory communication, but they're in fact the product of emergent animal group behaviour known as flocking. Every change of direction comes not as a result of an individual member of the flock, but rather of the snap decisions made by those individuals in response to the movements of their neighbours.

To comprehend how it works, in 1986 American computer programmer Craig Reynolds applied simple rules to bird behaviour to simulate flocking in his computer program Boids. The three rules he outlines include the fact that each bird steers itself to avoid crowding or bumping its neighbours (separation), each bird tries to match the average heading of its neighbours (alignment), and that each bird steers towards the average position of its neighbours, maintaining flock structure (cohesion).

The benefit of the flock

There are several benefits to flying as a flock. It improves a bird's chance of survival against predators because a large group of birds is stronger and better protected and with many eyes the flock is far more likely to spot a would-be marauder. Also, the predator will find it harder to concentrate on a single victim, increasing the individual member of the flock's chance of survival.

Flocking also enables birds to fly further using less energy because when the strong leader bird flaps its wings it creates uplift for the birds behind – each bird (except the leader) is flying in the up-wash from the wing of the bird in front. This enables the flock to use less energy and reduces fatigue.

Don't park you car under here!

© Science Photo Library

5 TOP FACTS FLOCKING

1 When to watch
The best time of year to witness flocking is winter as migratory birds prepare to head for warmer climes, and those that stick around for winter will be foraging and roosting together.

2 Honk honk
Sometimes geese at the back of their flock will make honking sounds to encourage the birds ahead to maintain their speed.

3 Sort Sol
Twice a year in Denmark massive flocks of starlings block out the sun during an event called Sort Sol or 'Black Sun'.

4 Movie sims
Craig Reynolds' Boids program inspired the film *Batman Begins* to simulate a swarm of bats. It was also the simulation behind the stampede of wildebeest in *The Lion King* animation.

5 Big flocks
There are more sub-Saharan red-billed Queleas in the world than any other species and their flocks can comprise tens of thousands – the flock can take hours to pass by.

Bird migration

Guided by stars and driven by genes, birds embark on epic annual journeys

Birds don't migrate because of the cold. A little snow won't actually kill them, but a scarce food supply will. Birds migrate to follow the bugs, worms or baby rabbits, but the "why" of migration isn't nearly as fascinating as the "how".

There are two skills that all migratory birds must possess: orientation and navigation. Orientation is the ability to determine the direction in which you're travelling. Birds don't have compasses or GPS devices, but they can orient themselves using the position of the Sun by day and the stars at night. Some birds, like pigeons, can orient themselves against the Earth's magnetic field.

As for navigation, there are several theories, but no definitive answers. Some birds are believed to 'pilot' from one point to the next using large landmarks like coastlines, mountain ranges and even four-lane highways. Other birds learn the migration route by following older birds that have already made the trip. But the most remarkable birds are those who are born with a mental map imprinted into their DNA, able to make difficult long-distance journeys without any outside assistance.

Soaring birds like hawks and pelicans do most of their flying during the day to capitalise on rising thermal drafts. Smaller birds that rely on powered flight mostly fly at night when the atmosphere is more stable.

"He's finished washing the car, commence bombing run now"

© Sciencephotolibrary

Birds orientate themselves using the sun by day and the stars by night

© Sciencephotolibrary

Migration routes

There are nearly as many migration routes as there are species of migratory birds. Almost all routes have a north-south orientation, since most birds are escaping their northern breeding grounds in the late fall to settle into their wintering territory further south. In North America, there are four main 'flyways' guiding birds from Northern Canada down to Mexico and South America. In Europe, many species breed near the arctic and follow dozens of routes to winter in the African plains.

Other routes aren't so easy. The short-tailed shearwater draws a looping figure of eight across the Pacific Rim. California gulls breed in Yellowstone National Park and fly west before turning south to their Southern California breeding ground (the direct route would take them over inhospitable desert.) But no migration route can top that of the tiny arctic tern, which travels from Greenland to Antarctica along the African and South American coasts, often covering more than 81,000km each year.

Innate vs learned behaviour

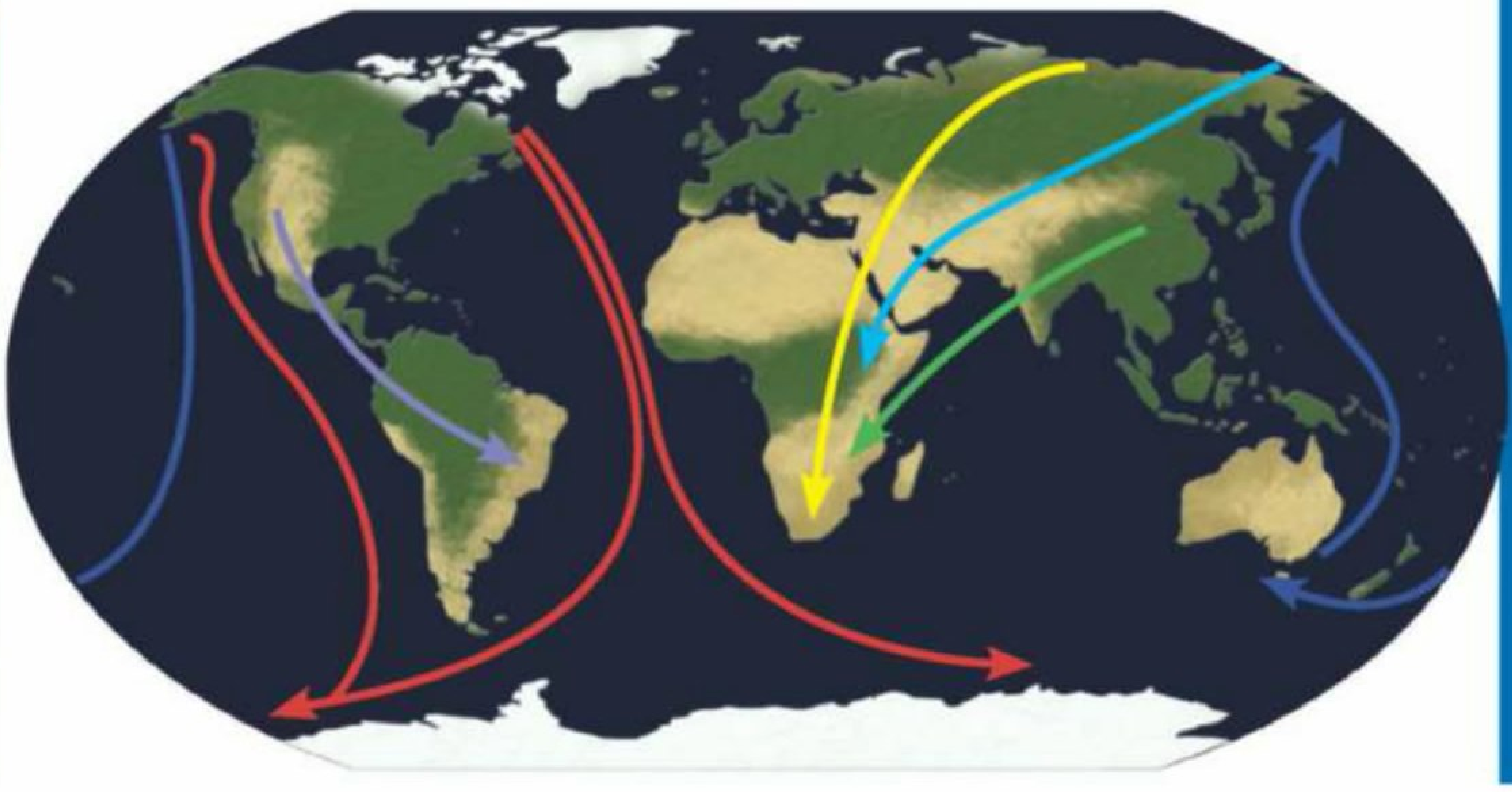
What we commonly call 'instinct' is the same thing animal researchers term innate behaviour. The lives of most insects, birds and even mammal species is wholly dominated by behaviour biologically inherited through their DNA. Although we attribute bird migration to the change of seasons and temperature, even captive birds with no access to natural light or shifting temperatures exhibit zugunruhe or 'migratory restlessness' at the same time as their wild brethren.

Animals can, however, learn to build on their own innate intelligences. Sheep dogs are natural herders, but become highly efficient if trained by a shepherd. Wild orangutans are born with excellent vocal and visual communications skills, but can be taught to apply those same skills using computer programs.

ON THE MAP

Which birds go where?

Northern wheatear	16,000km	Alaska to Africa	🟦
Arctic tern	80,000km	Greenland to Antarctica	🟥
Amur falcon	11,200km	North East Asia to Africa	🟩
Short-tailed shearwater	11,200km	South Australia to Alaska	🟦
Ruff	9,600km	Siberia to South Africa	🟨
Swainson's hawk	8,000km	North America to Brazil	🟪



Quicker and more reliable than the Royal Mail...

Sxc.hu

How homing pigeons navigate

The birds that use an internal clock and compass to make it home?

A homing pigeon is the domesticated variety of rock pigeon (Columba livia). The bird has been selectively bred since at least the Middle Ages in order to enhance its natural homing ability, for both domestic mail services and military communications. In order to navigate, the pigeon needs two things: a map and a compass. The map tells it where it is now and the compass lets it know which direction it needs to fly to make it home.

The compass aspect uses the position of the Sun, cross-referenced with the time of day, determined by the pigeon's own biological clock. If the weather is overcast, homing pigeons also have a weak magnetic sense, picked up by the trigeminal nerve in the head.

The map, however, is much harder to pinpoint. Experiments have variously shown that pigeons use local visual landmarks, wind direction, and the smells in the air to orient themselves. These cues are combined to form a mental map that improves as the bird is trained and can extend for hundreds of miles from the home loft.

Hummingbirds

Like a cross between bird and insect, the hummingbird can beat its wings up to 80 times every second, but how?

Hummingbirds are tiny fliers that can flap their wings extremely fast – so fast in fact that they can hover. Not only that, the hummingbird can also fly up, down, sideways, backwards, and even upside down. The reason they can achieve such exceptional flight patterns is that they can rotate their wings in a circle, creating power on the upstroke as well as the downstroke. Hummingbirds use their unique 'hands', which are long bones at the end of their arms that support the wing. The wing itself is flexible at the shoulder but not at the wrist, helping the bird beat them fast without any bending.

5 TOP FACTS
HUMMINGBIRDS

1 Variety
There are around 330 different species of hummingbird – and most are found in central and southern America.

2 A busy day!
The average hummingbird can flit from bloom to bloom and pollinate up to 2,000 flowers in a period of 24 hours.

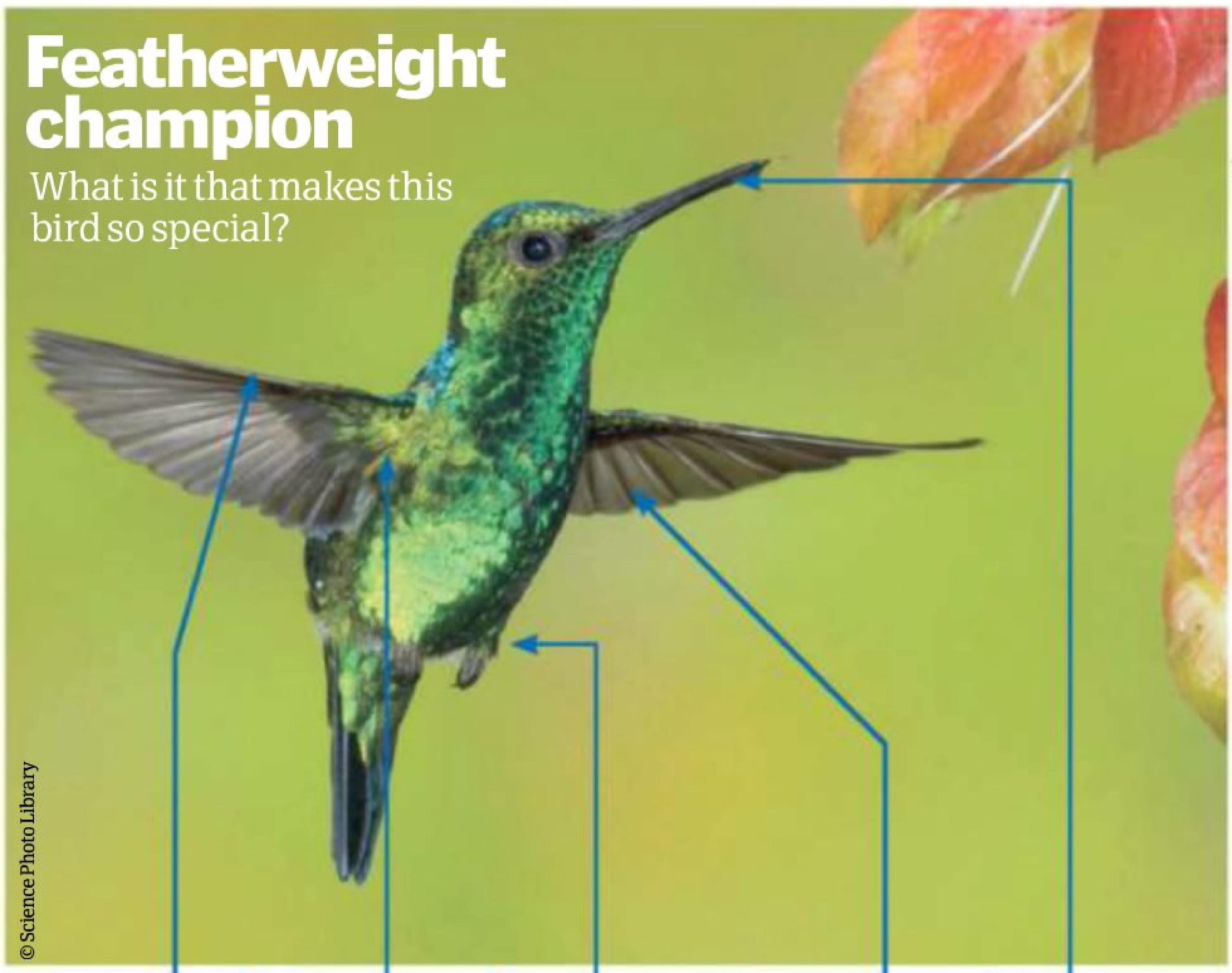
3 Heart of the matter
Just like humans, hummingbird hearts have four chambers, enabling very efficient oxygen transport. The hummingbird's heart can beat at 500 beats per minute (at rest!).

4 Fast flappers
Small hummingbirds can beat their wings 40-80 times per second, larger species 20-30 times and the giant hummingbird beats its wings as 'few' as ten times a second.

5 Feeling peckish?
Hummingbirds have the fastest metabolism of any other creature and so consume up to three times their own weight each day. Time between feeds can be just ten minutes.

Featherweight champion

What is it that makes this bird so special?



© Science Photo Library

Hands These very long bones support the main wing feathers and allow the bird to beat its wings extremely quickly without having to bend the wings.

Feathers Hummingbirds have a huge number of iridescent feathers but no down. Their tail feathers act as a paddle for steering while airborne.

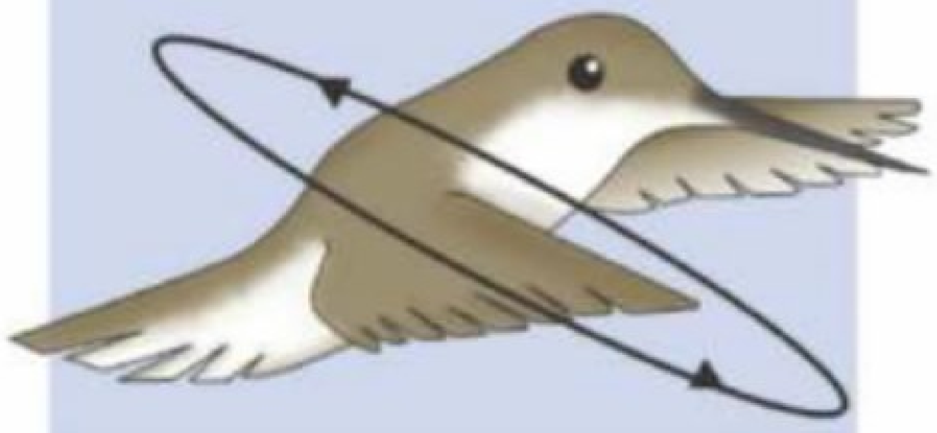
Feet Hummingbirds do have feet, which they use for perching and scratching, but they cannot use them for walking – they fly literally everywhere.

Wings Hummingbirds have short 'upper arms' and their elbow and wrist joints don't move. The shoulder joint can rotate 180° and move in all directions.

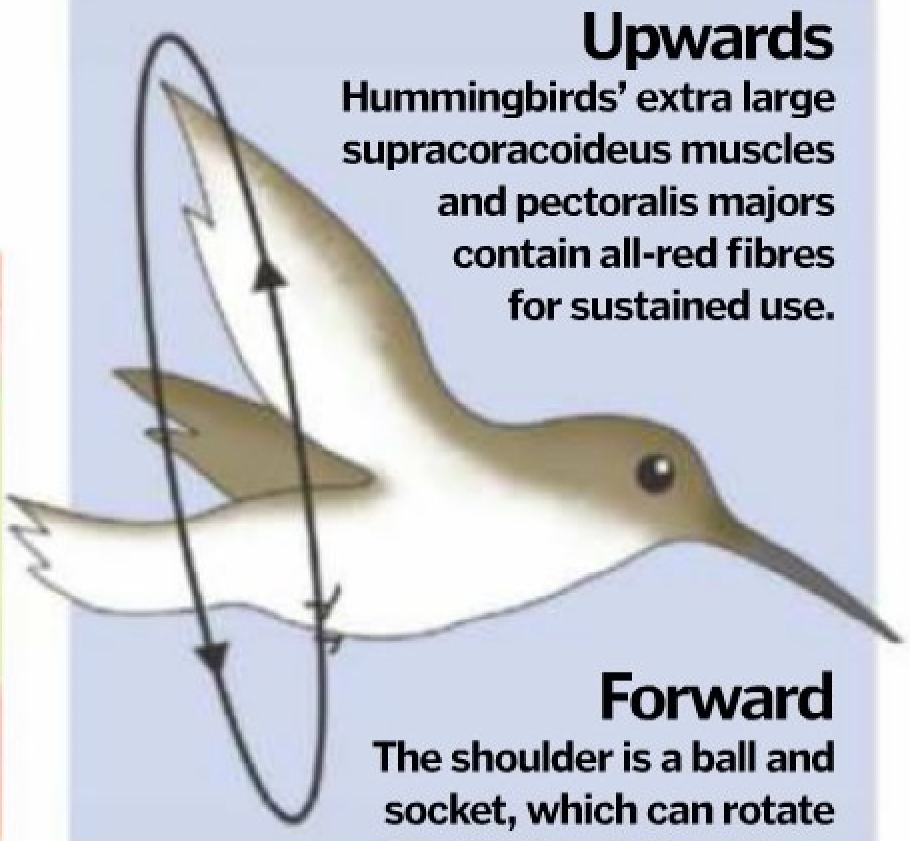
Bill Hummingbirds feed on sweet nectar that they industriously collect through their especially long tapered bills and straw-like, hairy tongues.

Flight patterns

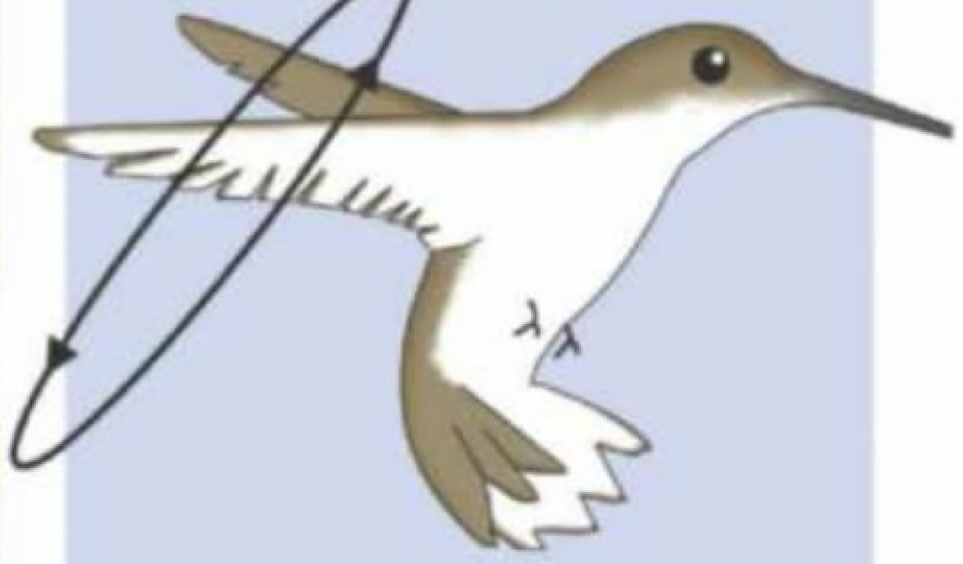
Hummingbird anatomy enables unique flight



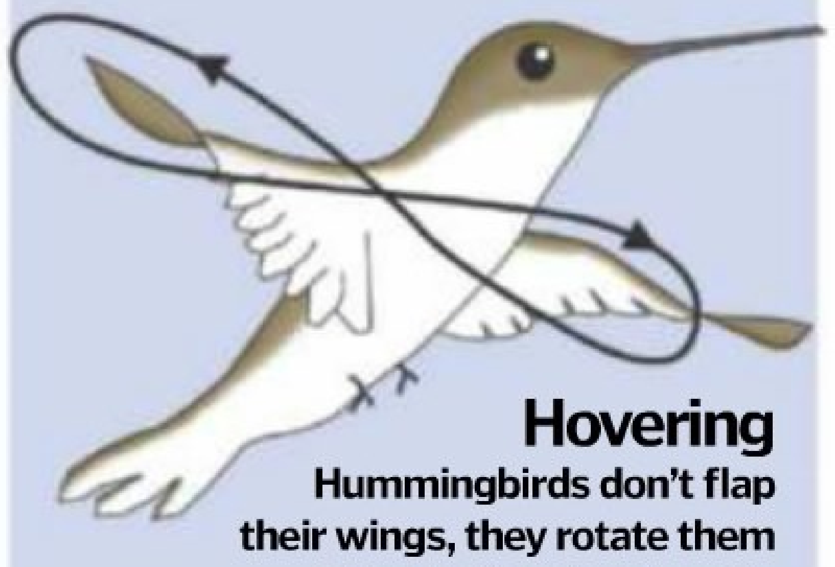
Upwards
Hummingbirds' extra large supracoracoideus muscles and pectoralis majors contain all-red fibres for sustained use.



Forward
The shoulder is a ball and socket, which can rotate 180° in all directions.



Backwards
Hummingbirds fly with their bodies held upright.



Hovering
Hummingbirds don't flap their wings, they rotate them using their unique hands.

The lyrebird's song

The bird that can replicate the noises it hears – from other birds to chainsaws felling trees

Birds get their vocal skills from the syrinx organ, the equivalent of a human's larynx. The lyrebird contains the most complicated syrinx of the songbirds (passerines), allowing it to mimic almost any sound. The syrinx, found at the base of the trachea, is surrounded by an air sac that produces the resonant sound when a lyrebird sings, while muscles move the syrinx and adjust the tension on highly elastic vibrating membranes. There are two species: the 80cm (31in) or so superb lyrebird, and the slightly shorter Albert's lyrebird, both of which are found in Australia. Male lyrebirds build a mound of dirt that acts as their amphitheatre and then mimic songs and man-made noises, like camera shutters and chainsaws, as they dance in order to draw female attention.

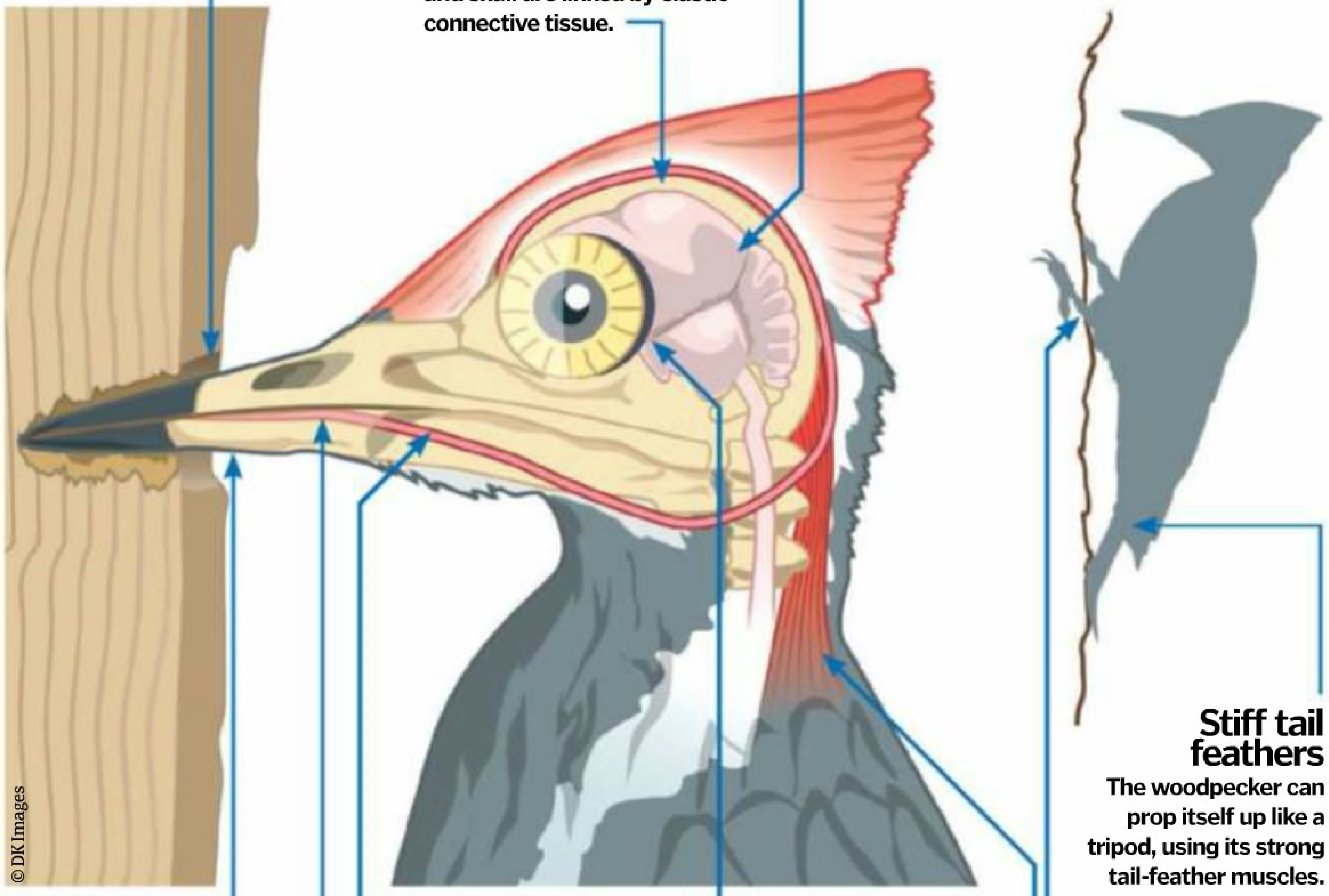
The all-singing, all-dancing lyrebird

© Caspian Blue

Woodpeckers explained

Woodpeckers whack their heads against wood up to 20 times a second, at 1,200 times the force of gravity, without suffering concussion, detached retinas or any other symptoms of head injury. But why?

Woodpeckers' tongues have longitudinal muscles for side-to-side movement when poking around for insects



© DK Images

Holes
Woodpeckers excavate small rectangular holes on the sides of tree trunks, prying off wood to expose tasty beetle larvae and carpenter ants.

Skull
Woodpeckers have a thicker skull than most other birds. It's made of extremely strong yet spongy compressible bone, to help cushion the blow. The beak and skull are linked by elastic connective tissue.

Brain
Unlike human brains, which are floating about in a pool of cushioning cerebrospinal fluid, woodpecker brains are tightly enclosed in the skull with practically no cerebrospinal fluid.

Stiff tail feathers
The woodpecker can prop itself up like a tripod, using its strong tail-feather muscles.

Beak
The strong bones that comprise the woodpecker's straight bill are strengthened by a horn-covered beak, which hammers into the wood and bark of a tree at something like 12,000 impacts per day in search of bugs and ants.

Hyoid apparatus
Within the long tongue is a skeletal structure called the 'hyoid apparatus'. This is a collection of small bones supported by cartilage and muscles, which fold up like an accordion and enable the woodpecker to stick its tongue out further.

Third eyelid
Woodpeckers have a thick inner eyelid, which acts as a seatbelt to ensure the bird's eyeballs don't pop out and also prevents tearing the retina. The eye is filled with blood to support the retina.

Zygodactyl feet
For optimum insect foraging, woodpeckers' feet are zygodactyl, which helps them cling onto vertical tree trunks. Zygodactyl means they have two front-facing toes and two back-facing toes.

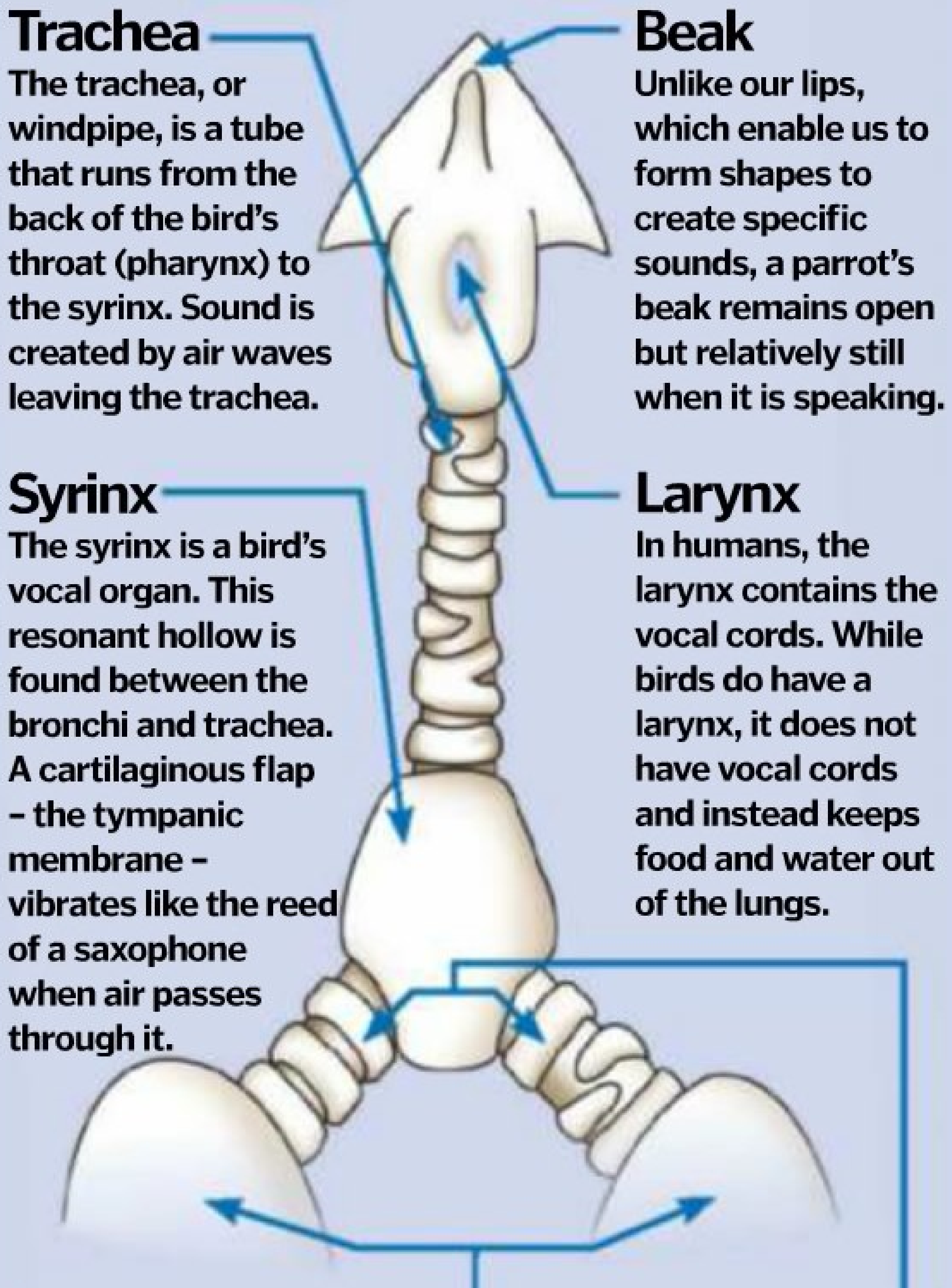
Barbed tongue
Because a woodpecker probes around inside tree trunks for insects, its barbed tongue needs to be longer than its beak – sometimes up to four times longer. In some species the tongue actually forks in the throat and disappears below the base of the jaw, wrapping up and over the head before rejoining behind the eye socket or nostril.

Neck muscles
A split second before every tap, the dense muscles in the bird's neck contract and distribute the force of the impact away from the skull down through the rest of the body, like shock absorbers.

How are parrots able to talk?

Discover the physiology of this bird that enables it to mimic human speech

While parrots do seem to make noises that sound like words, they do not create the sound in the same way that we do. For starters, birds possess neither a voicebox nor vocal cords. Instead they have a vocal organ called the syrinx lower down the throat. When air is expelled from the parrot's lungs across the syrinx, a wide range of noises can be formed. Located at the bottom of the trachea, just before the lungs, the syrinx is a bony structure whose walls vibrate as air passes through it. Parrots use the muscles around the syrinx (at the base of the trachea and the top of the bronchi) to change the shape and depth of the space, producing a multitude of different sounds. Changes in resonance come from the variations in air pressure, which is controlled by the bird's lungs.



Trachea
The trachea, or windpipe, is a tube that runs from the back of the bird's throat (pharynx) to the syrinx. Sound is created by air waves leaving the trachea.

Beak
Unlike our lips, which enable us to form shapes to create specific sounds, a parrot's beak remains open but relatively still when it is speaking.

Syrinx
The syrinx is a bird's vocal organ. This resonant hollow is found between the bronchi and trachea. A cartilaginous flap – the tympanic membrane – vibrates like the reed of a saxophone when air passes through it.

Larynx
In humans, the larynx contains the vocal cords. While birds do have a larynx, it does not have vocal cords and instead keeps food and water out of the lungs.

Lungs
Sound is produced by air passing through the syrinx from the lungs. Birds can control the air pressure in each lung individually, enabling them to adjust the resonance of the sounds they make. This also means they can make more than one noise at a time.

Bronchi
Air from the lungs travels through the two bronchi into the syrinx directly above the point where the bronchi branch off to each lung.

How owls hunt

Discover what makes this nocturnal bird of prey such a superior predator

The owl has evolved a number of traits that make it a masterful sky hunter. As well as being a keen territorial predator, with an intimate knowledge of the local terrain, the owl also has a number of physical characteristics that make it a formidable aerial assassin. Features include powerful talons, a sharp, hooked beak for rending flesh from bone plus heightened senses for locating and homing in on prey from above.

Super-sensitive hearing helps the owl pick up on the gentle rustling of small-footed prey such as birds, rodents and frogs far below. The extra-large disc-like shape of an owl's face with a ridge of feathers down the middle further improves hearing as sound waves are collected and channelled outwards towards the ears.

While we humans can hear sounds on a horizontal plane – ie we have the ability to tell whether a sound came from the left or right by turning our head in a particular direction to focus on the location of a sound, owls can hear things on a vertical plane. Species like the great horned owl, for example, have lopsided ears – with the left ear positioned slightly higher than the right, enabling them to accurately detect whether a sound originated from above or below.

Unlike the majority of other bird species, whose eyes are positioned on the sides of their heads, owls have front-facing eyes, giving them binocular vision and depth perception. This helps them get a fix on their quarry. They cannot, however, move their eyes in the sockets; instead they have the ability to turn their entire head some 270 degrees. This means they do not have to move the rest of their body to see what's going on behind them, which helps the birds to stay quiet. It's the ability to remain silent that gives an owl its greatest advantage when hunting.

The great grey owl lives in the taiga, a coniferous, snowy zone in the northern half of the planet that stretches from Alaska to Siberia

The statistics...

Owl

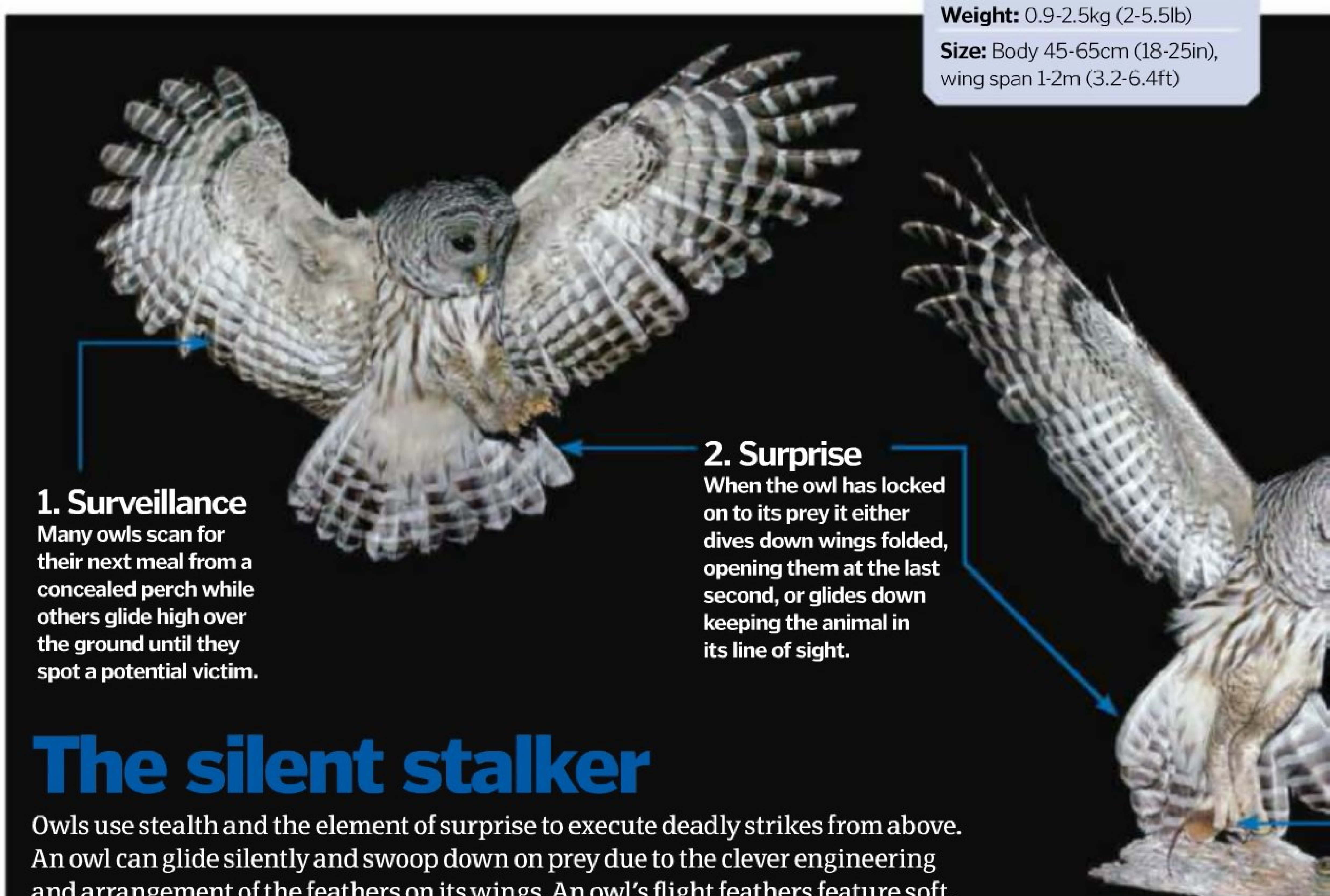
Type: Bird

Diet: Carnivore, including rodents, rabbits, snakes, fish, frogs and even other owls

Average life span in the wild: 5-15 years

Weight: 0.9-2.5kg (2-5.5lb)

Size: Body 45-65cm (18-25in), wing span 1-2m (3.2-6.4ft)



1. Surveillance
Many owls scan for their next meal from a concealed perch while others glide high over the ground until they spot a potential victim.

2. Surprise
When the owl has locked on to its prey it either dives down wings folded, opening them at the last second, or glides down keeping the animal in its line of sight.

The silent stalker

Owls use stealth and the element of surprise to execute deadly strikes from above. An owl can glide silently and swoop down on prey due to the clever engineering and arrangement of the feathers on its wings. An owl's flight feathers feature soft, serrated fringes that disrupt the turbulent flow of air over the wings. This reduces the noise produced as air flows over a smooth surface, making flight almost silent.

DID YOU KNOW?

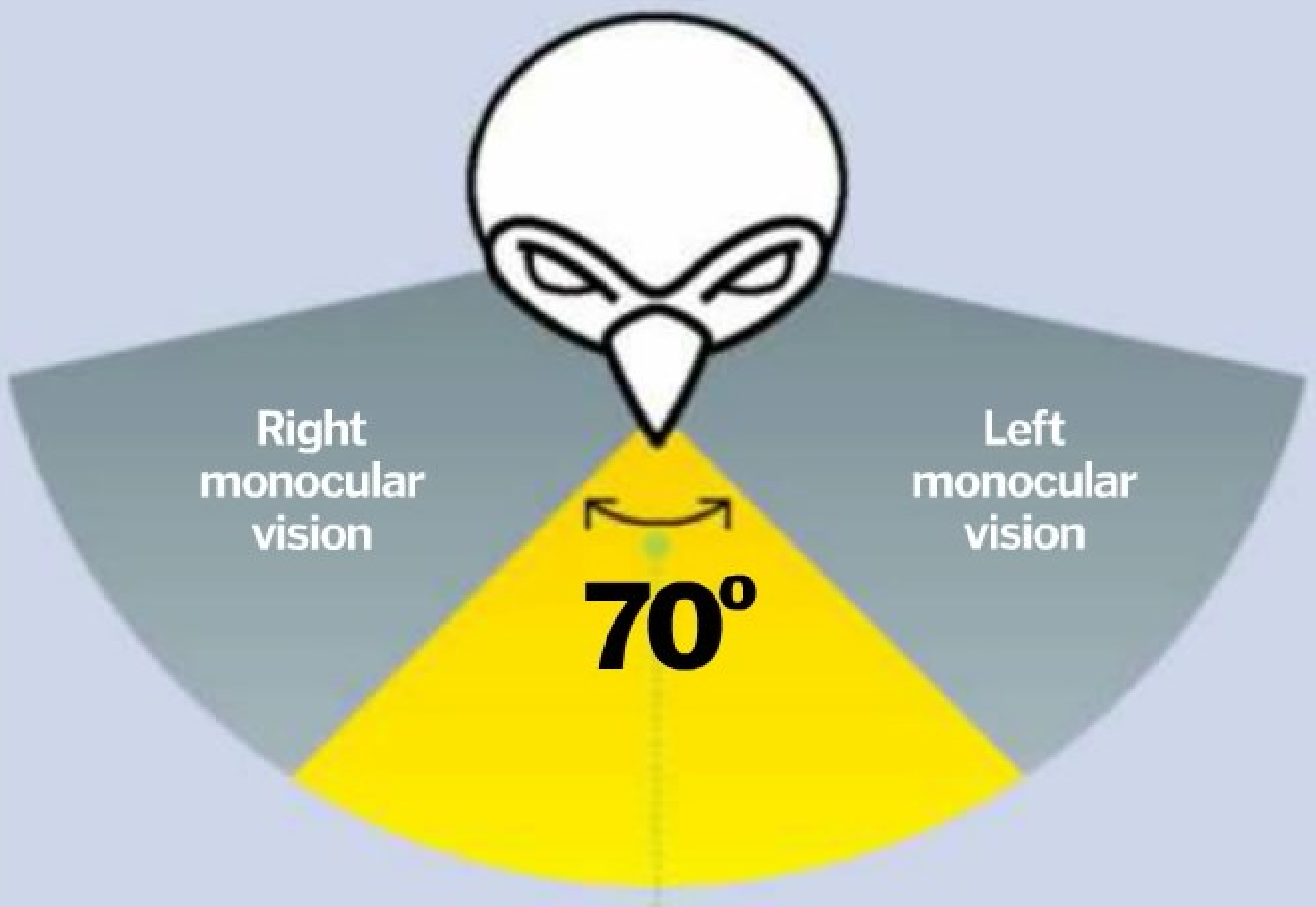
Dive-bombing owls

While owls remain generally out of sight during the day, there are occasional reports of them exhibiting aggressive behaviour, attacking or dive-bombing animals many times their size, including domestic dogs and even humans. Rather than attempting to kill and eat said humans, they are in fact defending their territory, mates, nests and/or chicks.

DID YOU KNOW? *According to the Guinness World Records, the newest bird of prey is the Socotra buzzard, discovered in 2010*

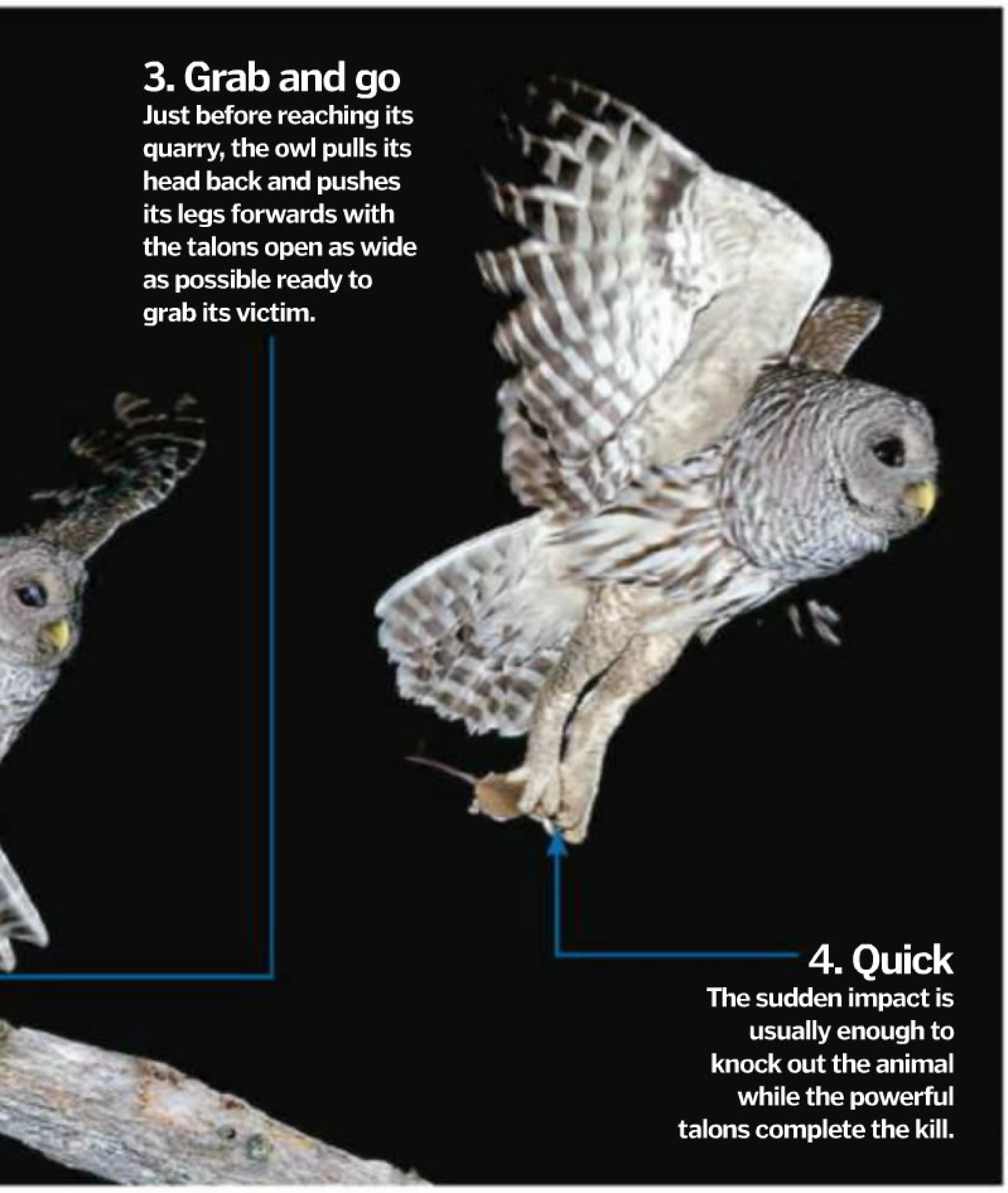
Seeing is believing

Owls have forward-facing eyes, like humans, and so this means they can see an object with both eyes at the same time. That is, their vision is binocular, as opposed to the monocular vision of most other birds whose eyes are located on the sides of their heads. As you can see from this diagram, owls have a wide field of view – around 110 degrees – but only about 70 degrees of this are binocular.



Binocular vision (70 degrees)

Owls have some of the best eyesight in the bird world. To put it into context, humans have an 180-degree field of vision, 140 degrees of which are binocular.



3. Grab and go

Just before reaching its quarry, the owl pulls its head back and pushes its legs forwards with the talons open as wide as possible ready to grab its victim.

4. Quick

The sudden impact is usually enough to knock out the animal while the powerful talons complete the kill.

© SPL

Pellets get rid of anything the owl can't digest

What are pellets?

You can discover a lot about what an owl eats from the pellets it spits out. These pellets contain the indigestible parts of an owl's diet. Birds of prey eat rodents and small birds. However, because they don't have teeth and cannot chew their food, they have to swallow things whole – that includes any fur, bones, feathers, claws and teeth. While other birds have a special organ called a crop, which is used for storing food for digestion later, owls do not have one of these. Instead, when an owl consumes food, it passes into the muscular gizzard called the ventriculus, a kind of secondary stomach full of small stones. The stones help to grind up the digestible food (which includes muscle, skin and organs) and digestive enzymes and acids dissolve the food so it can pass into the intestines. The leftover rubbish, which can't be broken down, is squeezed by the muscles of the gizzard and compacted into a soft pellet to be expelled from the body after many hours. The owl cannot eat again until the pellet has been coughed up, or regurgitated.

Learn more

'Hunters of the Sky', brought to Longleat Park by the Hawk Conservancy Trust, returned in 2012 with a brand new birds of prey show. This spectacular display of eagles, kites, vultures and owls fills the skies over Longleat; this is family fun at its very best! Open weekends only: 25 February-18 March. Open daily: 24 March-4 November. For more information on Longleat Safari & Adventure Park visit www.longleat.co.uk.

Interview Jimmy Robinson

Hawk Conservancy Trust curator Jimmy runs the 'Hunters of the Sky' bird of prey display at Longleat

What kinds of prey do owls usually like to eat?

Owls will eat a variety of different prey, normally depending on the size of the owl and where it lives. A barn owl mainly feeds on rodents while eagle owls will take prey like rabbits and even foxes on rare occasions.

What is the owl's most effective method or tactic for hunting down this kind of prey?

Many owls have silent flight. This is thanks to a comb-like edge to their flight feathers allowing air to pass through them; this reduces the noise of its flapping wings.

At what age is a young owl old enough to attempt its first kill?

At about four months old owls are catching prey for themselves. Some small species are fully feathered at ten weeks old. They grow up at an alarming rate and, once feathered, the race is on to be hunting as quickly and successfully as possible. In the wild it's survival of the fittest.

How and where do owls make their nests?

Owls nest in many different places. Barn owls nest in farm buildings or artificial nest boxes purposely put up to help them. Snowy owls, on the other hand, nest on the ground, while some species take over nests from other birds like crows.

What do owls do all day? How are they protected from predators?

Many owls are very well camouflaged. During the day the nocturnal owls will roost in a high tree or suitable safe place away from prying eyes.

What are the owl's main natural predators?

Other birds of prey, carnivorous mammals and reptiles like snakes will all look at owls as a suitable meal.

Do owls live up to their wise reputation?

Owls have incredibly large eyes; this enables them to see at night very well, but it does mean that the eyes take up much of the skull, leaving little room for the brain. Owls are not dim-witted, by any means, but are certainly not as wise as we're led to believe. There are many links to birds of prey and Greek deities; in fact, the little owl's Latin name links it to Athena, who was known as the goddess of wisdom.

2x © Longleat Safari & Adventure Park, Hunters of the Sky

How the condor survives

Discover the largest flying bird on the planet today

The condor, which falls into the New World vultures category, is a huge flying scavenger native to the wooded alpine and mountainous regions of the western Americas.

Being a carnivore, whose diet consists of the carcasses of bison and other large mammals, the condor relies on its ability to soar over vast distances with the help of a huge wingspan and the use of thermal columns. Thermals are masses of rising hot air that help carry this vulture to great heights – sometimes 4,600 metres (15,000 feet) at speeds of up to 88 kilometres (55 miles) per hour – so they can spot carrion across the widest areas. Despite being built for soaring over huge distances at great height, the condor doesn't have well-developed flight muscles and only really flaps to take off. Indeed, after a particularly heavy meal a condor may not be able to take off at all for a while.

Condors pair up for life and do not take new partners even after a mate has died. The condor nests at high altitudes to protect the egg (they only lay one at a time) from predators, but the egg is at risk from the extreme mountain weather. Parents share incubation duties and, once hatched, the chick will be raised by the parents for two years.

Both the Andean and Californian species of condor are endangered. While according to the IUCN Red List the Andean condor is currently near-threatened, the Californian condor is critically endangered and worsening due to a number of factors, including the growing danger of accidental ingestion of lead shot from carcasses that have been killed and left by hunters.

The statistics…

Condor

Type: Bird

Genus: Vultur gryphus

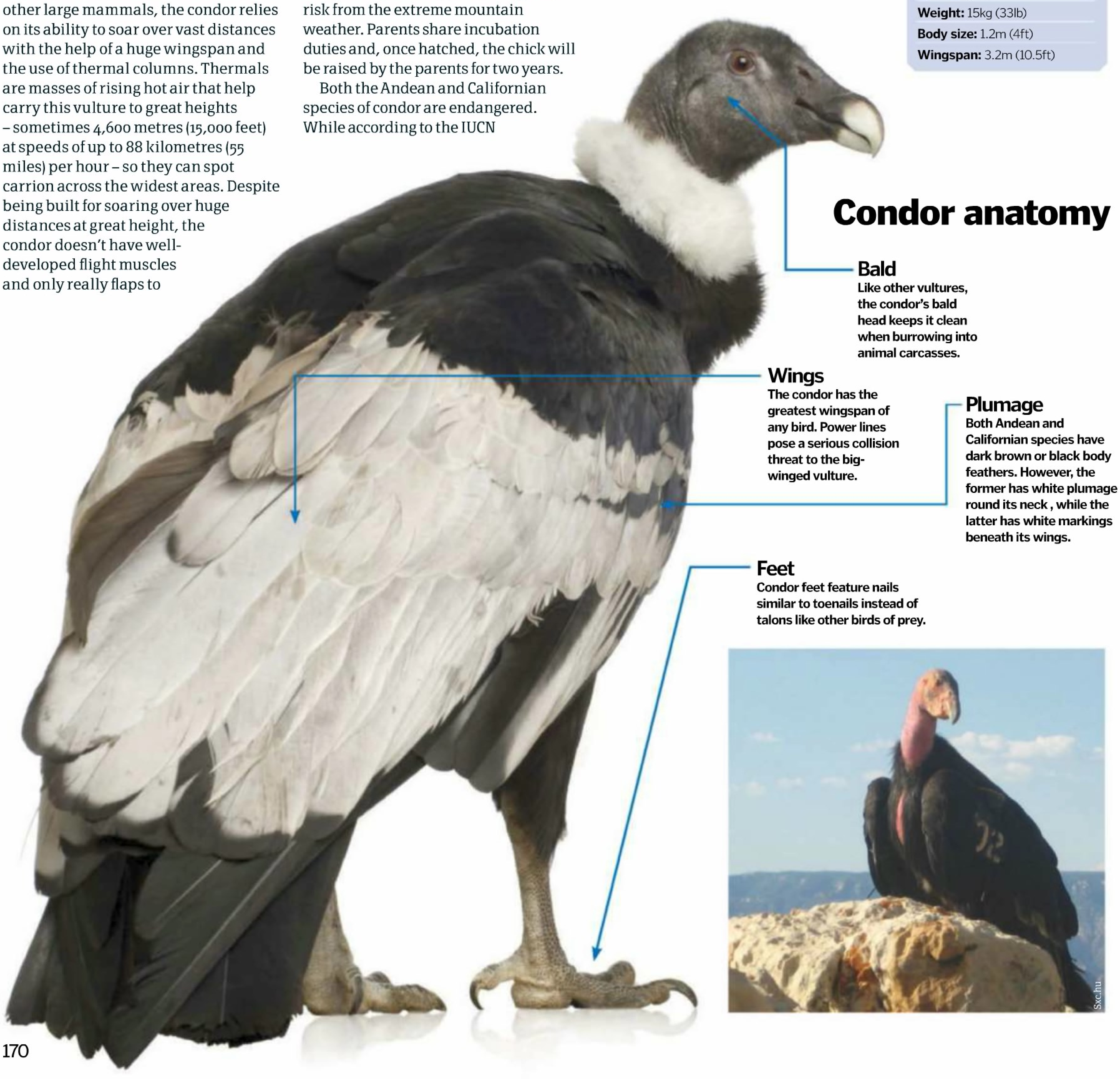
Diet: Carnivore

Average life span in the wild: Up to 60 years

Weight: 15kg (33lb)

Body size: 1.2m (4ft)

Wingspan: 3.2m (10.5ft)



Condor anatomy

Bald
Like other vultures, the condor's bald head keeps it clean when burrowing into animal carcasses.

Wings
The condor has the greatest wingspan of any bird. Power lines pose a serious collision threat to the big-winged vulture.

Plumage
Both Andean and Californian species have dark brown or black body feathers. However, the former has white plumage round its neck , while the latter has white markings beneath its wings.

Feet
Condor feet feature nails similar to toenails instead of talons like other birds of prey.

Sxc.hu

Head to Head VULTURES

© Petra Karstedt, 2005

1. King vulture

This bird lives in Central and South America and is popular in Mayan folklore. The yellow and red fleshy caruncle on its beak is used in mating displays.

© Vishal Sabharwal, 2007

2. Red-headed vulture

Found in Nepal and India, this species is endangered because of the drug Diclofenac, which is given to cattle but is toxic to birds.

3. Hooded vulture

This vulture has benefited from human association and can be found in huge flocks around waste tips in Sub-Saharan Africa.

DID YOU KNOW? *Vultures can projectile-vomit as a defensive weapon. The acid is strong enough to burn skin!*

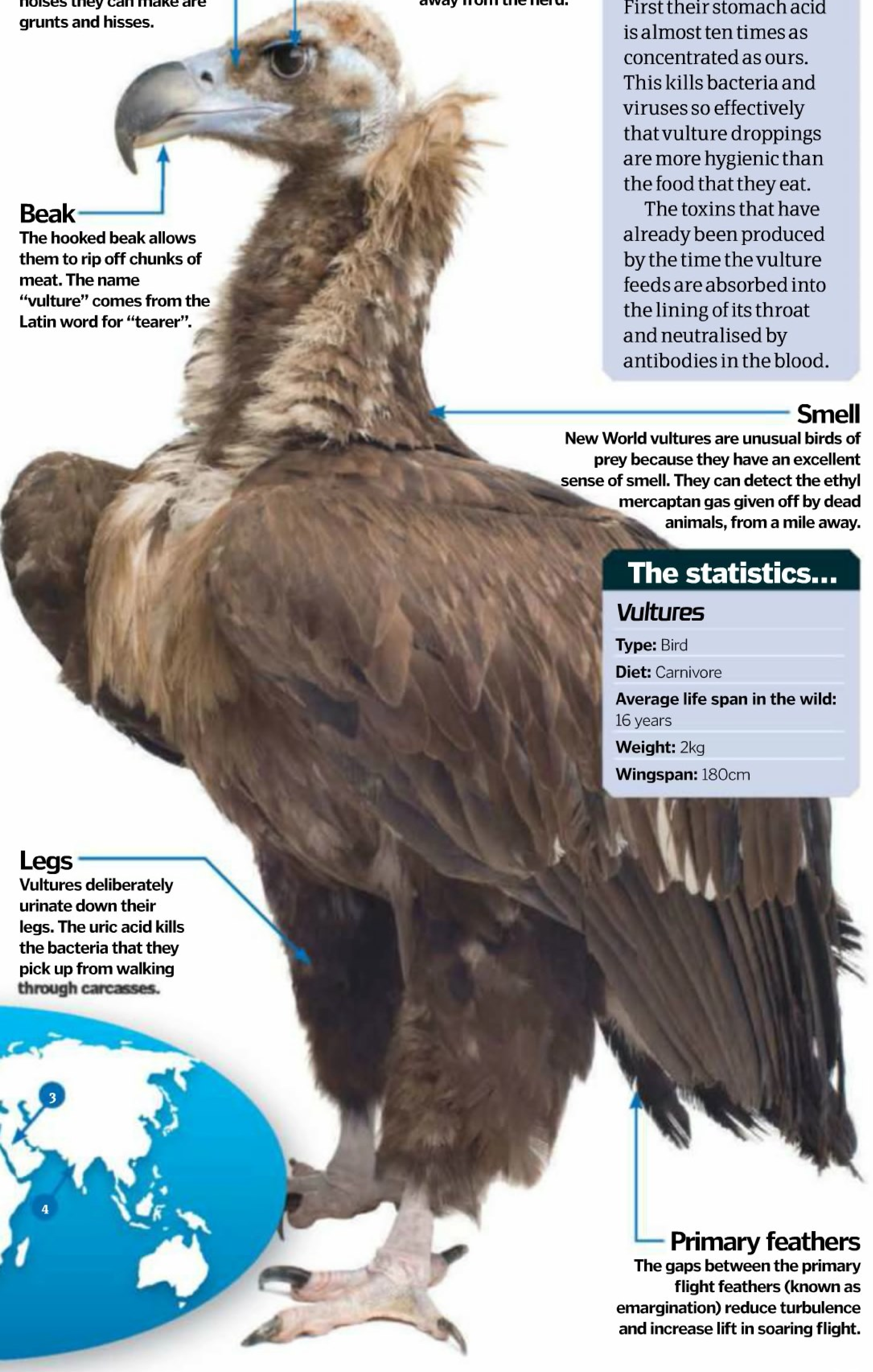
How vultures eat

They may be the ultimate scavengers but do they deserve their reputation as freeloaders?

Vultures live in ecosystems mainly comprising large grazers. That presents a problem for a carnivore because a 2kg bird cannot take down a 500kg buffalo. Their solution is to let other animals do it for them or to wait for their lunch to die of natural causes. This requires patience; vultures have large wingspans, adapted for soaring in thermals, so they can scan a huge area of grassland at once, looking for a dead or dying beast. Vultures do not strictly hunt but if they come across a weakened animal they will have no objection to tucking in straight away, hastening the demise of their meal. After they have gorged themselves, vultures will perch sleepily on rocks or in trees, digesting and waiting for a big enough thermal to help them launch aloft once more.

Although the vultures found in the Old World and the New World look quite similar, this is because they have evolved to tackle the same evolutionary niche. New World vultures include the condors and aren't genetically very closely related to the Old World species.

Vultures feed by plunging their heads into the body cavities of large animals. A feathery head would become impossibly matted with blood and juices, interfering with the vulture's vision and risking an infection that could lead to death . A side effect of evolving a bald head is that a vulture can use its neck to regulate its body temperature, extending and hunching to adjust the amount of heat that is lost through the exposed skin.



Voice
Vultures don't have a syrinx – the voice box found in other birds – so the only noises they can make are grunts and hisses.

Vision
Old World vultures locate dead animals exclusively by sight, homing in on animals lying still, away from the herd.

Beak
The hooked beak allows them to rip off chunks of meat. The name "vulture" comes from the Latin word for "tearer".

Smell
New World vultures are unusual birds of prey because they have an excellent sense of smell. They can detect the ethyl mercaptan gas given off by dead animals, from a mile away.

Legs
Vultures deliberately urinate down their legs. The uric acid kills the bacteria that they pick up from walking through carcasses.

Primary feathers
The gaps between the primary flight feathers (known as emargination) reduce turbulence and increase lift in soaring flight.

A strong stomach

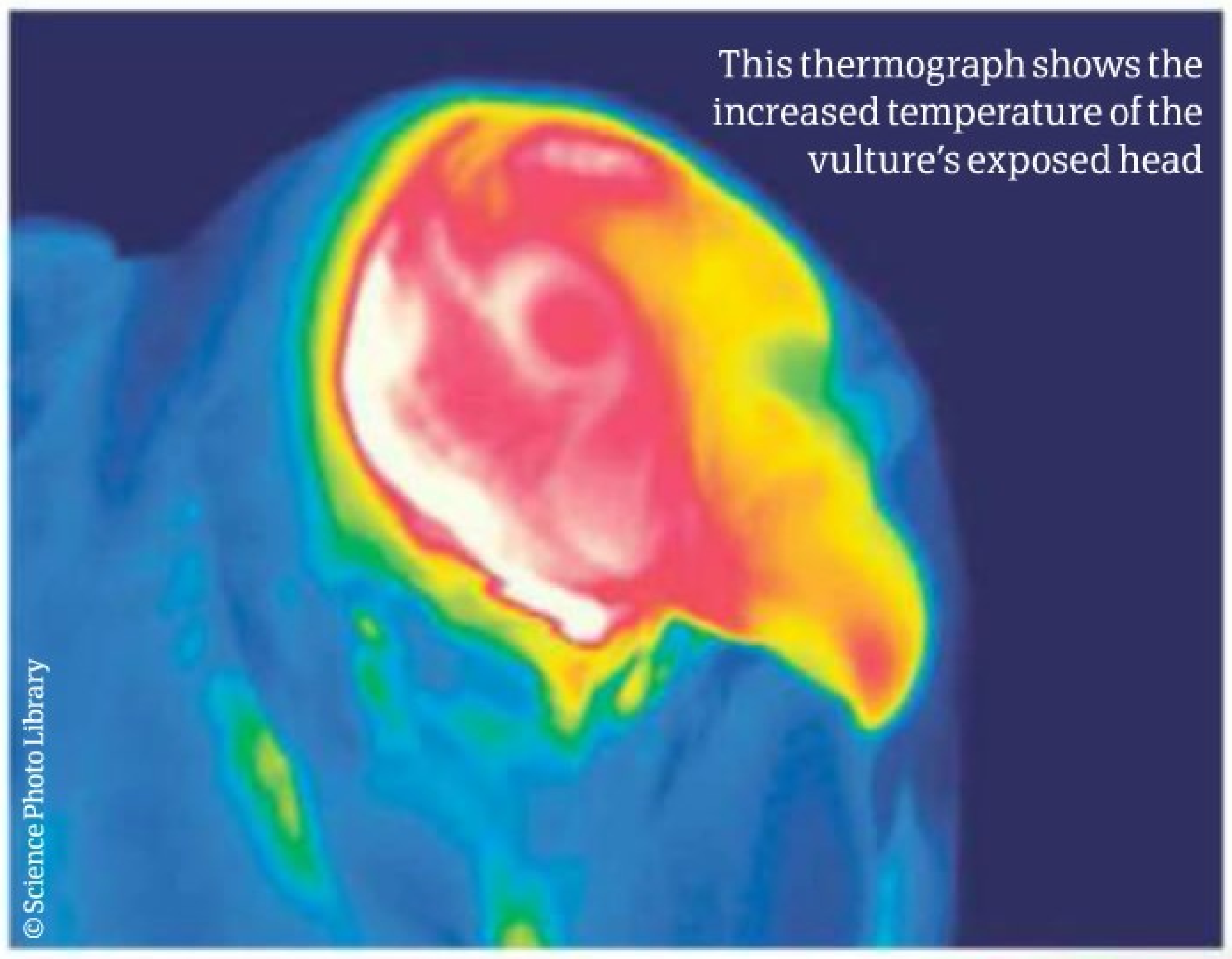
Vultures eat animals that may have died naturally weeks ago. This putrid flesh is often so riddled bacteria that it would be lethal to any other animal. Vultures protect themselves against this in two ways. First their stomach acid is almost ten times as concentrated as ours. This kills bacteria and viruses so effectively that vulture droppings are more hygienic than the food that they eat.

The toxins that have already been produced by the time the vulture feeds are absorbed into the lining of its throat and neutralised by antibodies in the blood.

The statistics…

Vultures

Type: Bird
Diet: Carnivore
Average life span in the wild: 16 years
Weight: 2kg
Wingspan: 180cm



This thermograph shows the increased temperature of the vulture's exposed head

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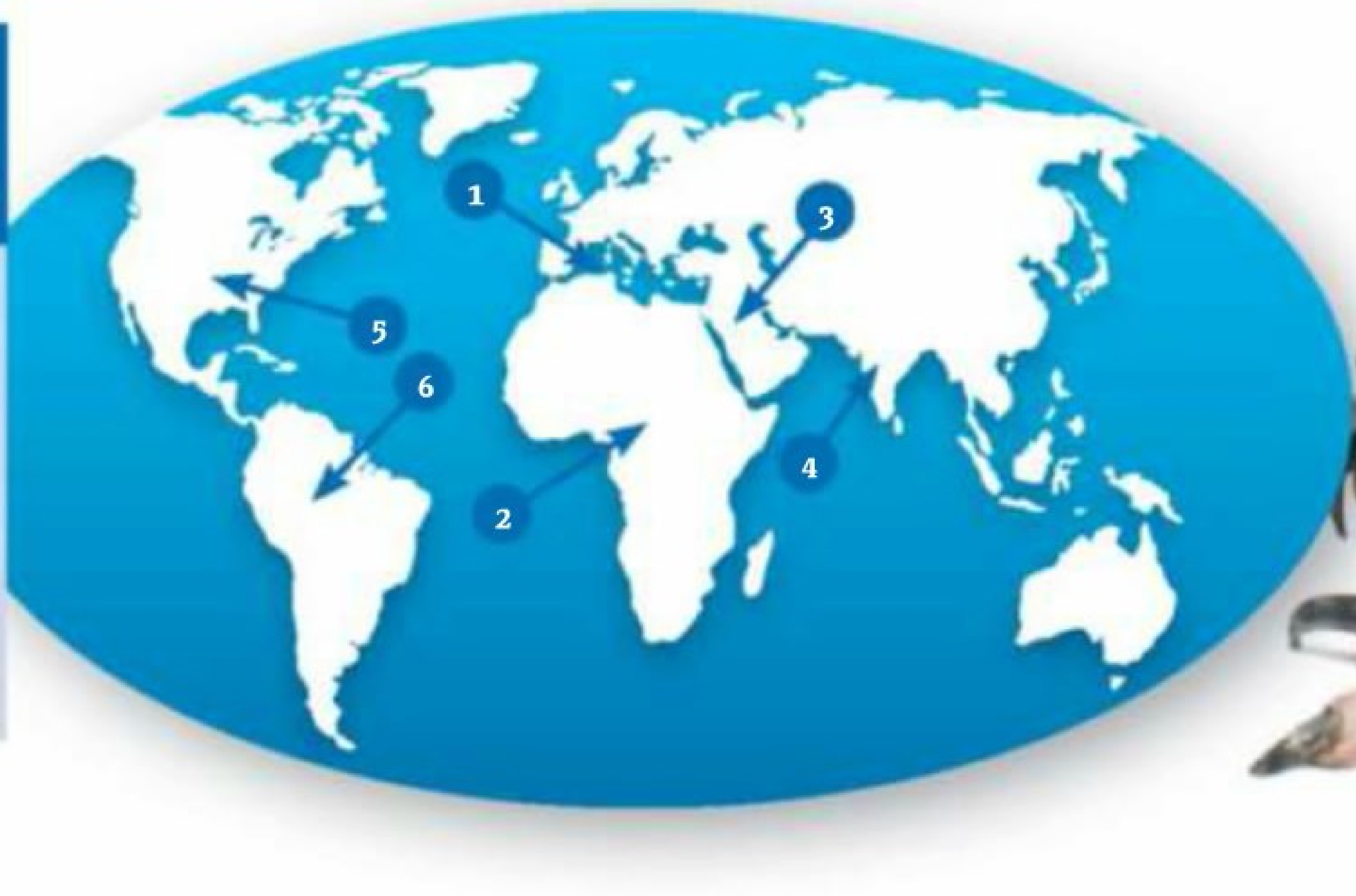
ON THE MAP



Where to find vultures

1 Southern Europe and North Africa
2 Sub-Saharan Africa
3 Middle East
4 Indian subcontinent
5 USA
6 Central and South America

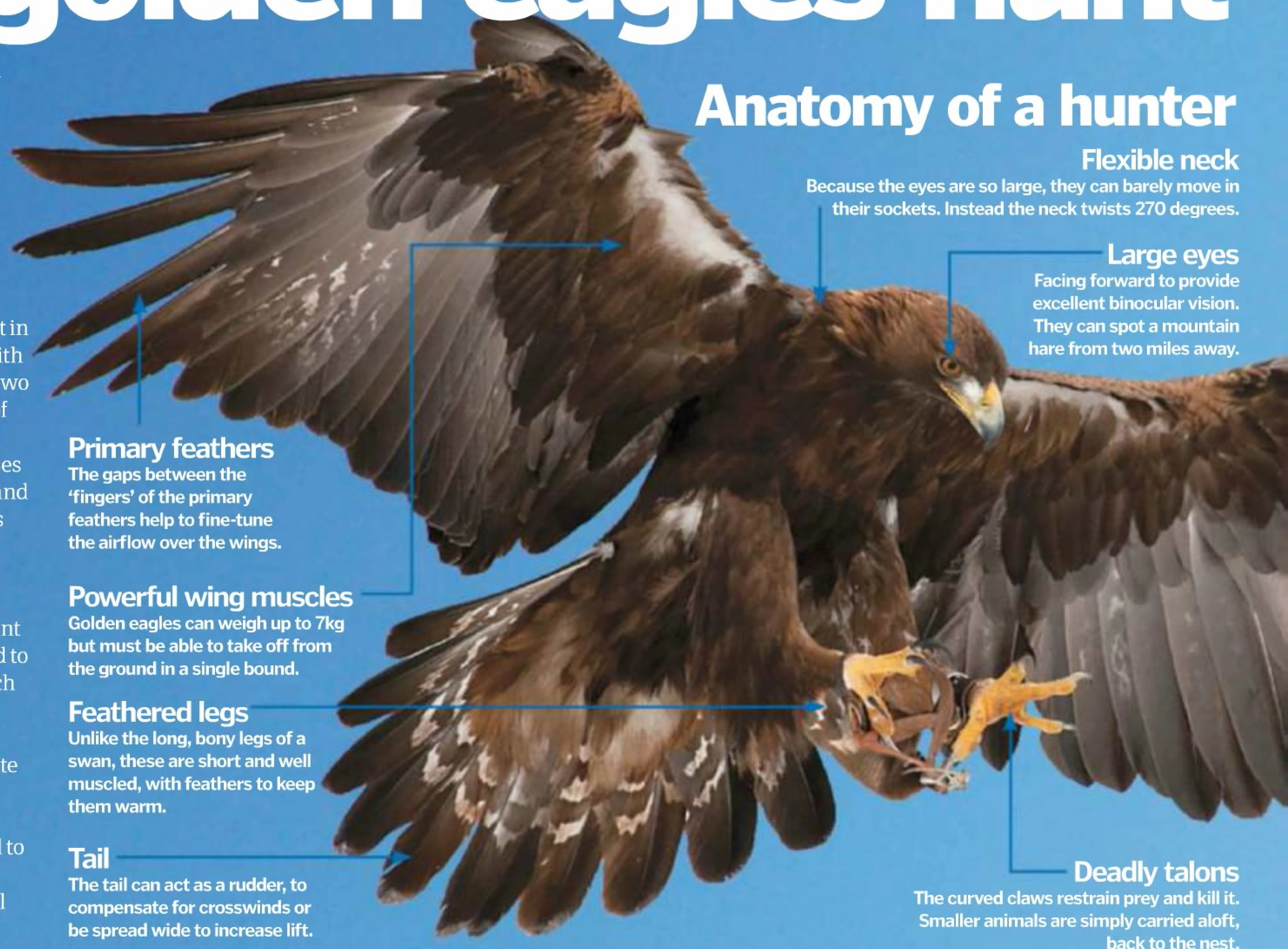
How golden eagles hunt

Telescopic vision and terrifying talons: be glad you're not a Scottish rabbit

Golden eagles are apex predators, adapted to hunt in very harsh landscapes. With a wingspan of more than two metres, they are huge birds, capable of lifting prey weighing as much as five kilograms. There are documented cases of golden eagles attacking adult deer and even a bear cub but their usual targets are hares, foxes, grouse and, on the coast, seabirds.

Golden eagles nest in trees and on remote mountain crags. They can't hunt in thick forest so they have specialised to scour moors and uplands. Food is much scarcer here and the eagles have to patrol huge territories; sometimes as much as $160km^2$. To do this they operate like stealth bombers, flying very high above the ground to scan a wide area without alerting their prey. They need to be able to soar for hours at a time and strong enough to kill whatever animal presents an opportunity.

Anatomy of a hunter



Flexible neck
Because the eyes are so large, they can barely move in their sockets. Instead the neck twists 270 degrees.

Large eyes
Facing forward to provide excellent binocular vision. They can spot a mountain hare from two miles away.

Primary feathers
The gaps between the 'fingers' of the primary feathers help to fine-tune the airflow over the wings.

Powerful wing muscles
Golden eagles can weigh up to 7kg but must be able to take off from the ground in a single bound.

Feathered legs
Unlike the long, bony legs of a swan, these are short and well muscled, with feathers to keep them warm.

Tail
The tail can act as a rudder, to compensate for crosswinds or be spread wide to increase lift.

Deadly talons
The curved claws restrain prey and kill it. Smaller animals are simply carried aloft, back to the nest.

Eagle-eyed hunters

Eagle eyes are very large, relative to their body size: if our eyes were similarly proportioned, they would be the size of oranges. They also have 600,000 cone receptors per mm^2 on their retinas – four times the density in human eyes. These factors combine to give golden eagles two and a half times better resolving power in their vision.

Golden eagles have a translucent second eyelid, called a nictitating membrane, which blinks sideways. In the last moment before the eagle strikes, this membrane closes to protect the precious eyes.

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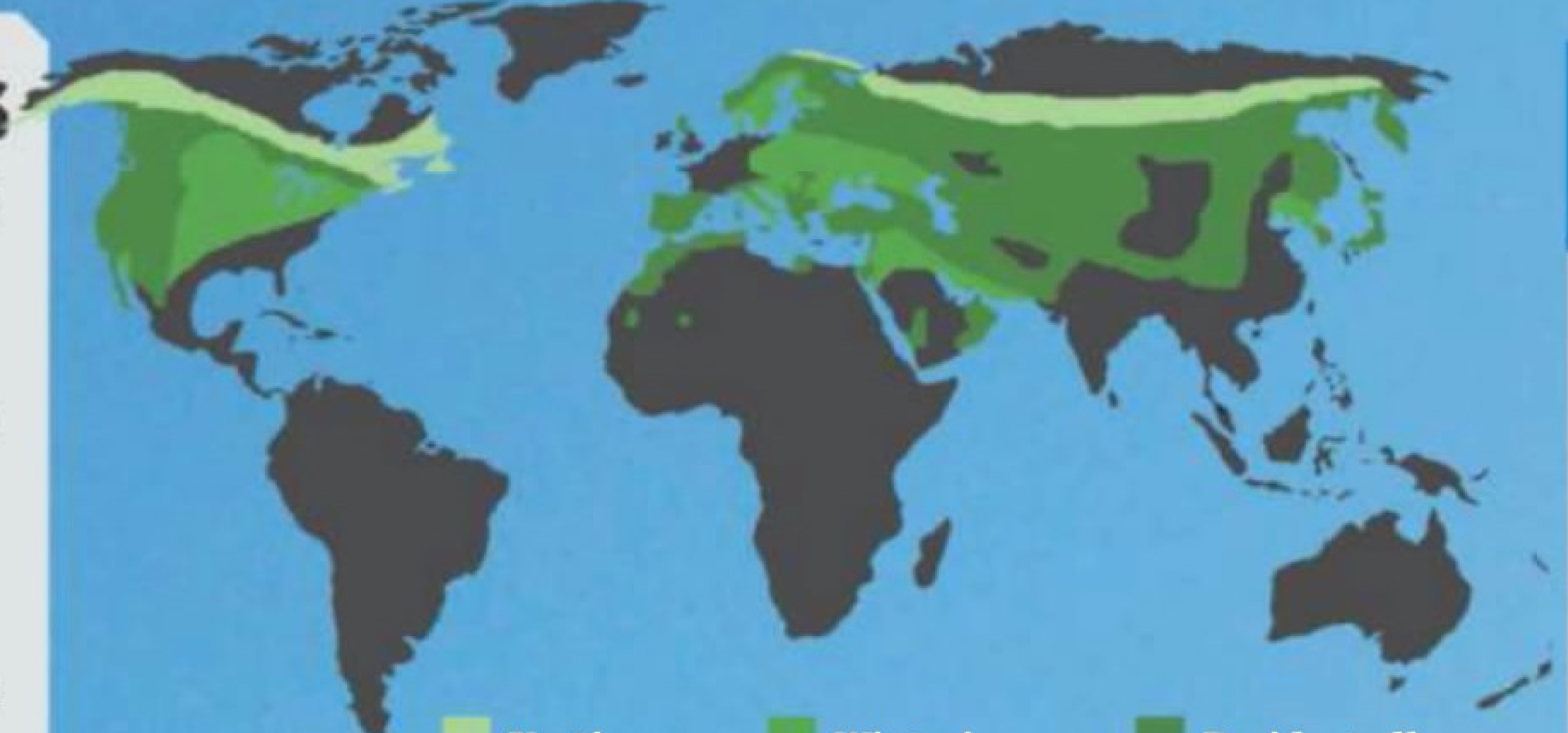


🟩 Nesting area 🟩 Wintering area 🟩 Resident all year

ON THE MAP

Golden eagles need wide open spaces with access to cliffs or trees for nesting but without dense woodland. In more northerly latitudes, this terrain can extend all the way down to sea level. Further south, golden eagles stick to the mountains.

Death from the sky

The golden eagle rarely attacks prey directly from altitude with a dive bomb or 'stoop'. Instead, it wheels out of the sky, some distance away and swoops in from downwind, close to the ground. The eagle relies on a sudden overwhelming attack. If it misjudges the initial strike, it's unlikely to prevail in a chase.

Golden eagles use the primary feathers on their wingtips to control the turbulent vortices of air along the trailing edge of the wings and increase lift. The eagle can spread its tail wide to merge with the wings into a single 'delta wing', or folded for maximum speed.

DID YOU KNOW? *Penguins only live in the southern hemisphere*

How do penguins swim?

Revealing the secret of the penguin's underwater prowess

The flippers are key to the penguin's swimming abilities

Don't hold the awful jokes against the bird, blame McVitie's

Though ungainly on land, the flightless penguin has physical characteristics perfect for swimming through water – fortunate, as some species are known to be at sea for up to 75 per cent of their lives. Spending so much time in the water puts penguins at risk from predators, so swimming skills are essential. While their long, streamlined bodies and short legs give them a clumsy gait when waddling on land, penguins' wings have a unique characteristic that gives them surprising agility in water.

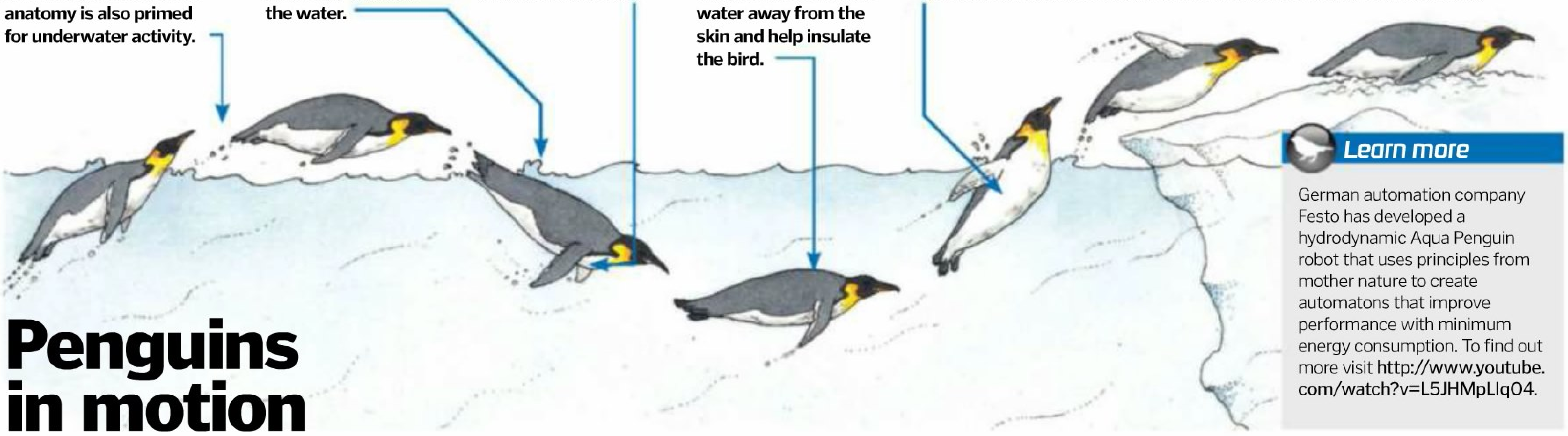
While penguins' wings are not suitable for aerial flight – mainly because, unlike the delicate lightweight bones of other birds, penguin bones are solid – they are perfect for soaring through water, with the Gentoo penguin reaching speeds up to 22mph. Referred to as flippers, the penguin's stiff wings act as the perfect natural paddle. What's most interesting, however, is the recent discovery that as well as being able to flap their flippers up and down like wings, penguins can also twist them in a corkscrewing motion.

The joint attaching the flipper to the body is similar to that of a human shoulder, enabling the bird to better control its movements and speed. A swimming penguin can rotate one flipper in one direction and the other in another, enabling it to turn instantly or stop suddenly. Twisting causes a greater surface area of the wing to move over the water, which generates a greater thrusting force so the penguin can increase its speed without the need for more flapping.

Another technique the penguin uses for moving through water is porpoising. Whenever it needs to breathe, the penguin will periodically swim fast under the water and then use its flippers to leap from the water in an arc. The momentum of porpoising helps penguins when they need to flee quickly from predators.

The humble penguin is one of the planet's best-equipped swimmers and the 'twisting flipper' motion is currently being applied by scientists who are looking to develop robot technology that helps to improve the efficiency and performance of underwater vehicles.

Penguins in motion



1. P-p-p-propel like a penguin

And it's not just the flippers that make the penguin such an able swimmer; the rest of its anatomy is also primed for underwater activity.

2. Body

A long fusiform, or torpedo-shaped, body helps the penguin glide gracefully through the water.

3. Flippers

The stiff yet flexible flippers are shorter than the wings of other birds, making them powerful oars.

4. Feathers

For every square inch of flesh a penguin can have up to 70 overlapping short, shiny feathers to keep water away from the skin and help insulate the bird.

5. Colouring

A penguin's striking colouration is essential for helping to keep it safe from predators in the water. If a killer whale looks up, it will not see the penguin because the light ventral underside blends in with the light from above. A predator looking down on a penguin, meanwhile, shouldn't spot the creature because the dark dorsal side blends in with the murky depths below.

Learn more

German automation company Festo has developed a hydrodynamic Aqua Penguin robot that uses principles from mother nature to create automatons that improve performance with minimum energy consumption. To find out more visit **http://www.youtube.com/watch?v=L5JHMpLIqO4.**

© DK Images

How do penguins survive?

They can endure freezing temperatures, 100mph winds and go without food for months, but what makes these birds so tough?

Known for being a sociable, loyal and really rather tough little creature, the penguin is a resilient member of the flightless bird club. 18 species of penguin can be located throughout the southern hemisphere, ranging from as far south as the coast of Antarctica and as far north as the Galapagos Islands in the Pacific. The smallest species is the appropriately named fairy penguin, which makes its home in the coastal waters of Australia. The biggest member of the family, meanwhile, is the emperor penguin, which lives a somewhat more treacherous life on the perilous frozen continent of Antarctica.

When it comes to breeding, most penguin species (the emperor penguins do things differently; see 'Emperor penguin role reversal', opposite) care for usually one or two eggs in nests built from stones and vegetation. The parents take it in turns to fetch food and protect the eggs for the duration of incubation, which can be anything from 30-60 days. Then, once the chick is born, parents continue to share childcare duties for 2-13 months depending on the species.

Baby penguins won't be going anywhere near the ocean for around six months, or at least until their downy coats have been replaced with insulating, waterproof feathers. The adults therefore have to find and fetch food, which they regurgitate for the chicks. There are three main ways a penguin can bring food back for its young. Because they sometimes have to travel great distances to source fish and crustaceans, the penguin parents have developed a rather nifty way of consuming food out at sea and storing it in their stomachs in special enzymes that prevent it from being digested. Alternatively, they can also partly digest the food into a soft mush. Finally, penguins that have been feeding for weeks can fully digest the food but then secrete a nutritious oil for their young.

The penguin has a number of different predators, including leopard seals, killer whales, giant petrels, sharks and humans among others. Large scavenger seabirds called skuas will even work in teams to swipe untended eggs and unprotected chicks in the blink of an eye. One skua will provide a distraction, luring the adult penguins away from their helpless young, while another strikes, stealing eggs and newborns.

A hungry leopard seal will prowl for penguins at the edge of the ice

The statistics...

Emperor penguin

Type: Bird

Diet: Krill, shrimp and fish

Average life span in the wild: 10-20 years

Weight: Up to 40kg (90lb)

Size: Up to 1.2m (4ft)

Once the chick has hatched, both parents must work tirelessly to rear the young bird

5 TOP FACTS PENGUINS

Bowing

1 When a male and female penguin bow their heads together it is part of an elaborate courting ritual of head movements and calls that helps establish a strong bond.

Born to swim

2 Penguins have a fusiform (torpedo-shaped) body, which helps them tear through the water at high speed. Emperors are thought to be able to reach speeds of 14km/h (9mph).

Safety in numbers

3 As the ocean is teeming with predators, these birds swim in groups – adélie penguins even engage in a spot of synchronised swimming to look like one large creature.

The big moult

4 When a penguin is moulting, it can't go in the water so it may have to fast for up to a month while its feathers grow back. In preparation for this, the bird will eat as much as possible.

Counter-shading

5 A penguin's colouring is useful for both hunting and avoiding predators when at sea. The black dorsal side blends in with the dark ocean depths, while the white belly blends with the sky.

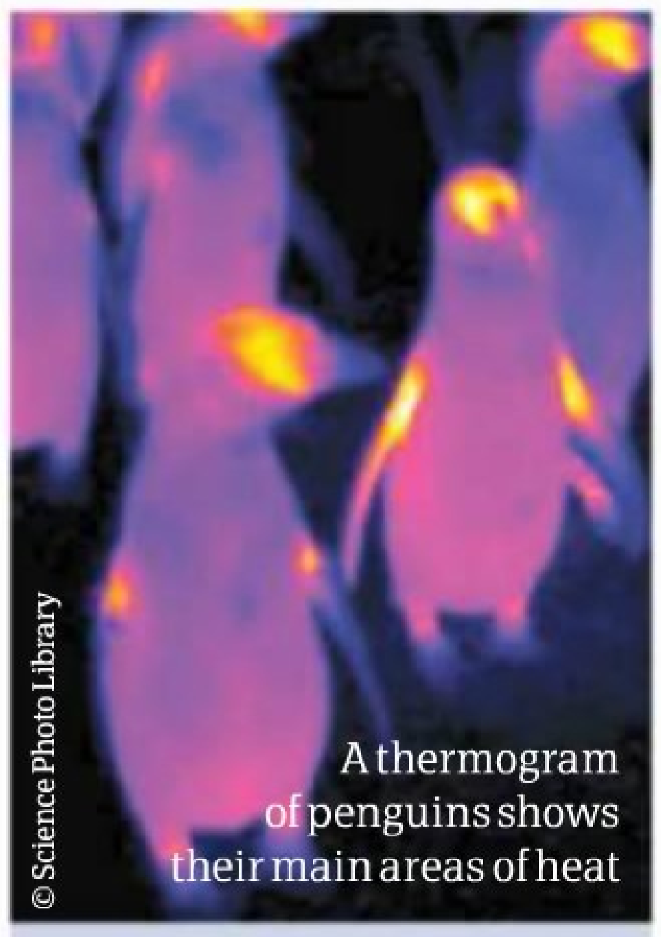
DID YOU KNOW? Penguins can sleep lying down or standing up with their head or beak tucked under a wing

A male emperor penguin incubates its egg, shielding it from the worst of the cold

Emperor penguin role reversal

Emperor penguins, native to the barren plains of Antarctica, must endure some of the planet's most extreme conditions on a continent known for its freezing temperatures and relentless high winds. So how do these hardcore birds breed in such bleak conditions? Well, emperors do things a bit differently.

The female will lay a single egg in early winter and instead of taking it in turns to look after the egg, like other penguins, the male emperor stays behind to incubate it while the female heads out across the ice for two months to find food. Huddling is essential for these penguins in order to overcome the elements. Once the emperor chick is born the huddling continues in the form of crèches – not only to keep warm but also as protection against predators. The babies come together in a large group with the adults around the edge.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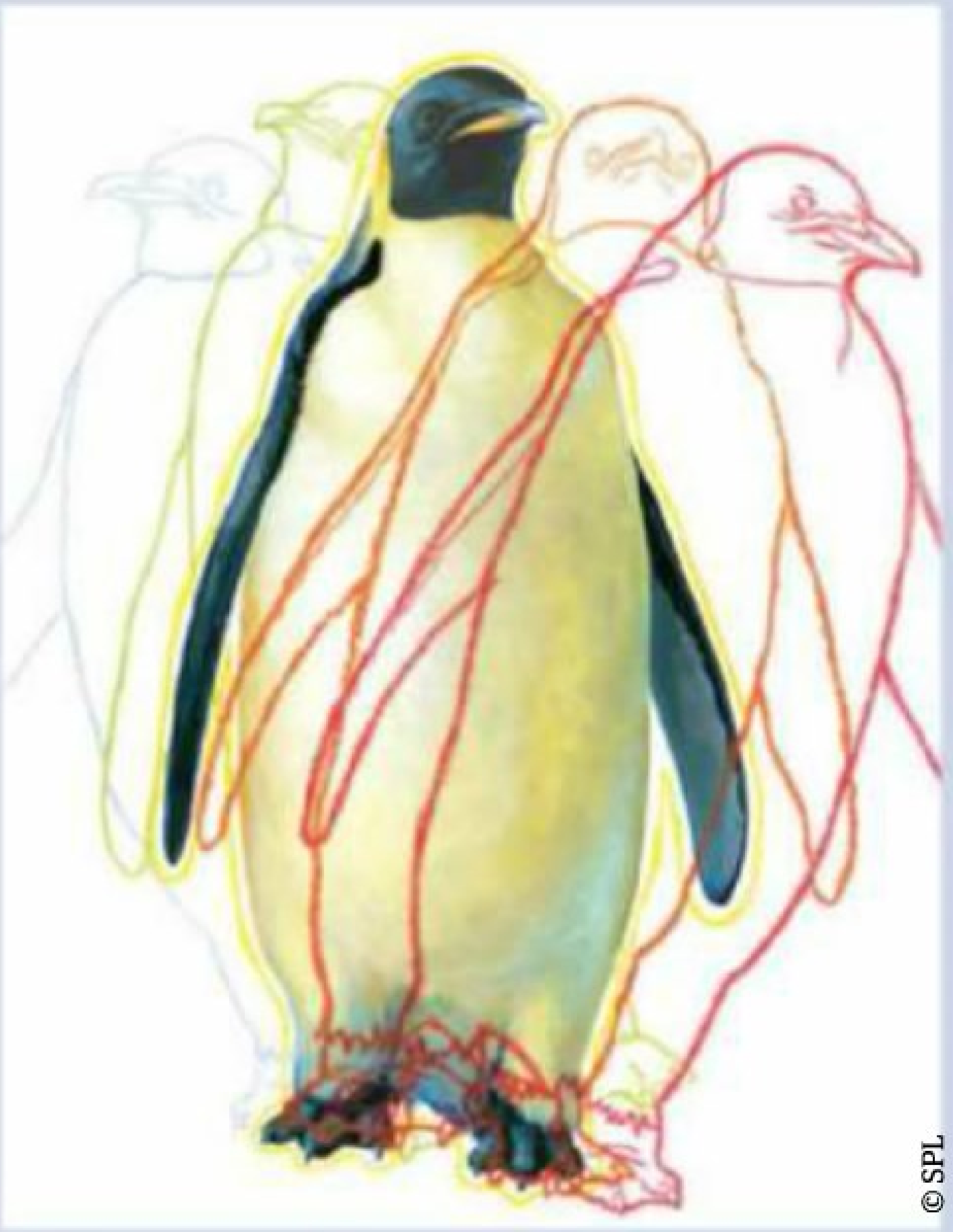
A thermogram of penguins shows their main areas of heat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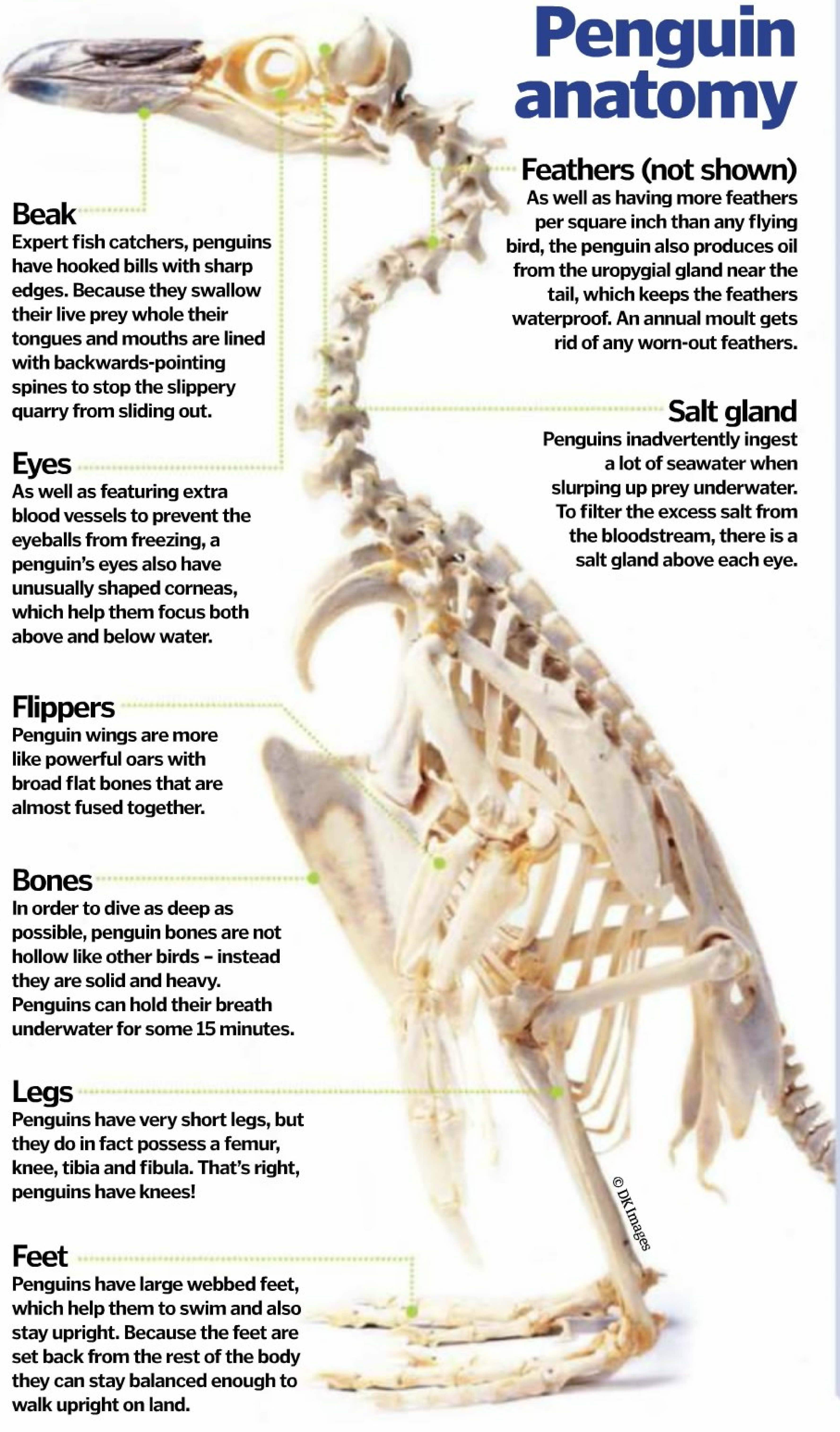
Do the locomotion

Penguins prefer swimming over flying, which is just as well because unlike airborne birds whose bones are hollow, penguins have dense skeletons; great for diving but not flying. Slick and streamlined in the water they may be, but when getting around on land penguins are undeniably inelegant. They traipse across land on foot using a unique combination of an awkward side-to-side waddle and a two-footed jump for navigating rocks and uneven surfaces. Antarctic penguins are known to travel up to 80 kilometres (50 miles) in search of food. Despite their short legs, they can scurry quite quickly. However, to save energy, penguins have a third method of travel: whenever the opportunity arises they will slide downhill on their bellies, using their wings to steer and their feet to propel themselves. This is known as tobogganing.

Penguin anatomy


© DK Images

Feathers (not shown)
As well as having more feathers per square inch than any flying bird, the penguin also produces oil from the uropygial gland near the tail, which keeps the feathers waterproof. An annual moult gets rid of any worn-out feathers.

Salt gland
Penguins inadvertently ingest a lot of seawater when slurping up prey underwater. To filter the excess salt from the bloodstream, there is a salt gland above each eye.

Beak
Expert fish catchers, penguins have hooked bills with sharp edges. Because they swallow their live prey whole their tongues and mouths are lined with backwards-pointing spines to stop the slippery quarry from sliding out.

Eyes
As well as featuring extra blood vessels to prevent the eyeballs from freezing, a penguin's eyes also have unusually shaped corneas, which help them focus both above and below water.

Flippers
Penguin wings are more like powerful oars with broad flat bones that are almost fused together.

Bones
In order to dive as deep as possible, penguin bones are not hollow like other birds – instead they are solid and heavy. Penguins can hold their breath underwater for some 15 minutes.

Legs
Penguins have very short legs, but they do in fact possess a femur, knee, tibia and fibula. That's right, penguins have knees!

Feet
Penguins have large webbed feet, which help them to swim and also stay upright. Because the feet are set back from the rest of the body they can stay balanced enough to walk upright on land.

Penguin central heating

Penguins are endothermic, ie warm-blooded, and regulate their temperature to both conserve energy and avoid freezing in a number of clever ways.

Penguin feathers are very numerous and very tightly packed, making them a bit like fur. At the base of each individual feather is a lot of downy fluff which traps air close to the penguin's thick skin. Not only that, but penguin feathers are also coated in a waterproof oil produced in a gland near the tail. Their thick skin has an extra layer of fat where energy is stored too. And penguins also work together to stay warm. Tens of thousands of penguins will huddle together in a huge colony to conserve their body heat, taking it in turns to shelter in the middle.

Penguins can adjust the amount of body heat they conserve and release too. To stay warm, heat from blood flowing to the feet is transferred to blood returning to the heart, which explains why penguins' feet don't freeze. Conversely, to cool down, blood vessels in the skin can dilate and move heat to the surface where it can be released.

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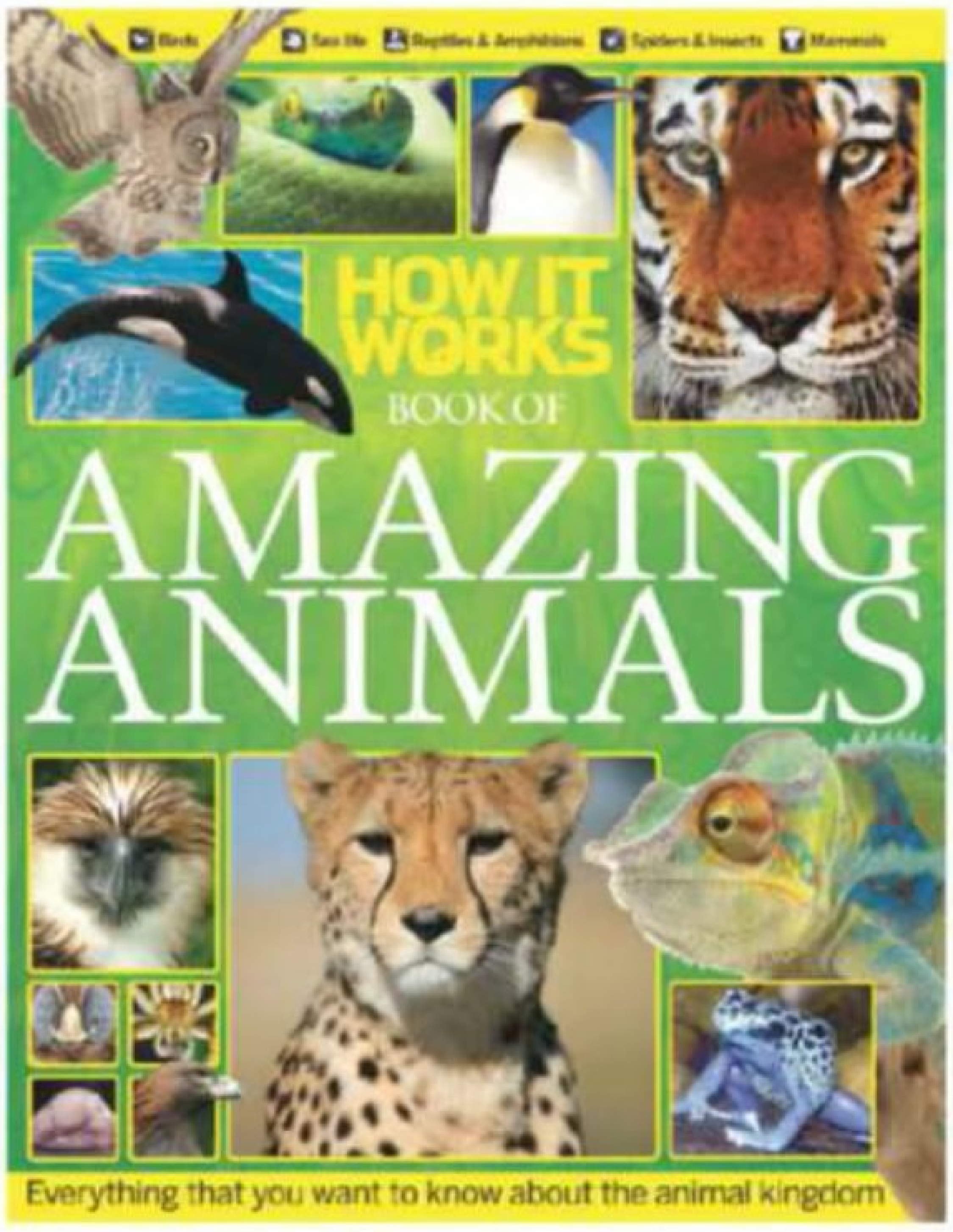

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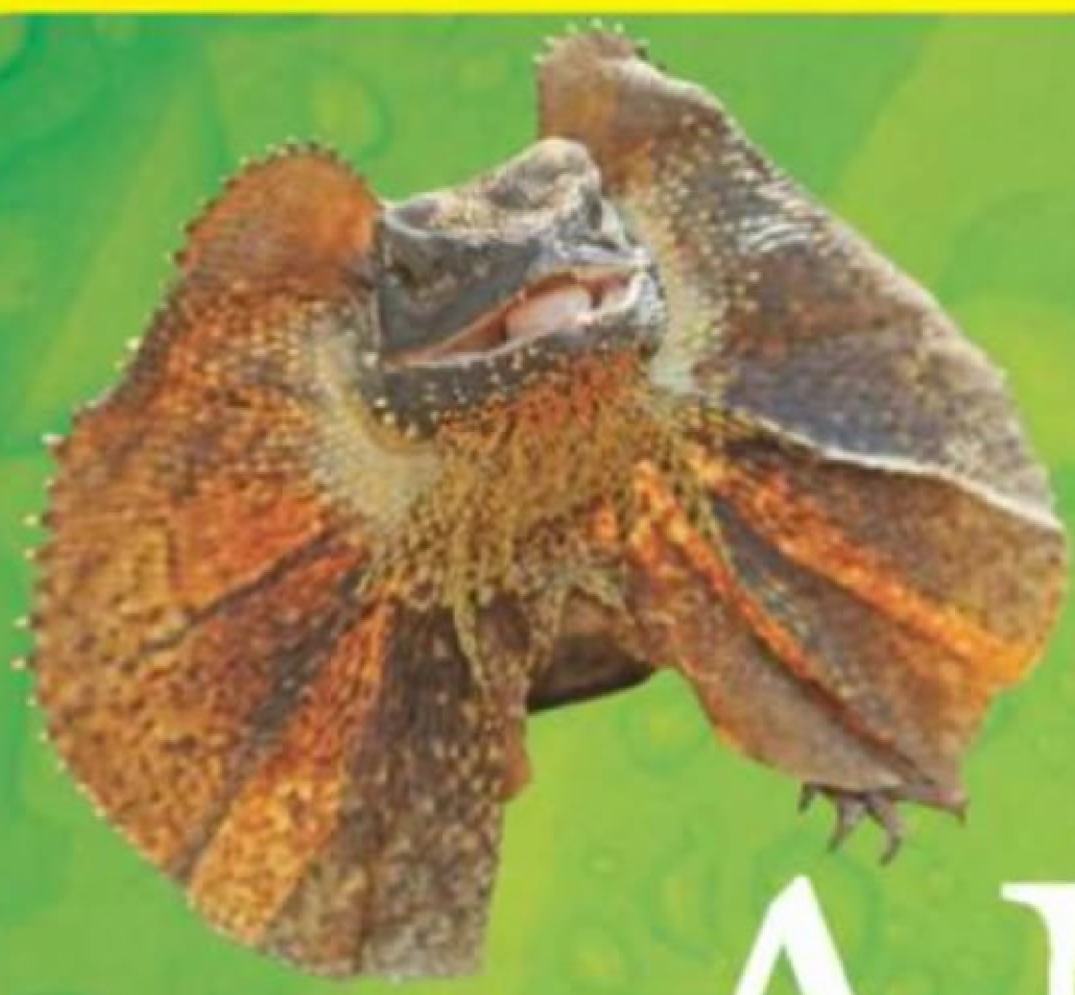

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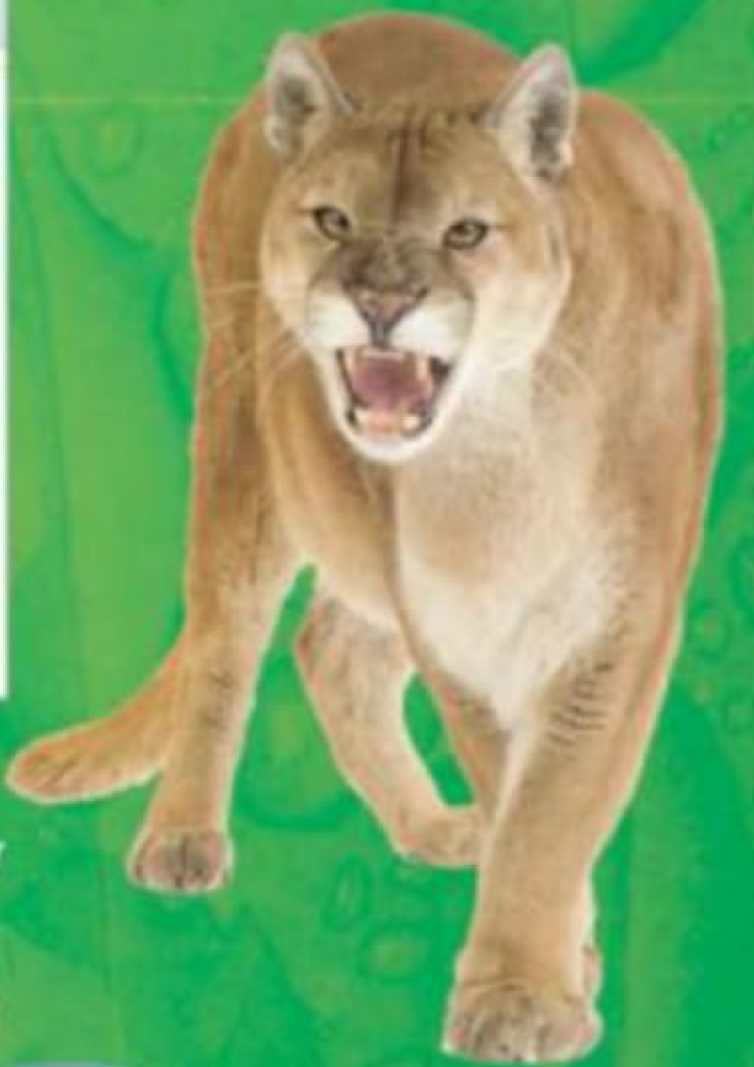

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